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PETROLEUM REFINER

SPECIALIZED FOR THE OIL REFINING INDUSTRY, INCLUDING PETRO-CHEMICAL ENGINEERING, PETROLEUM SYNTHETICS AND NATURAL GASOLINE

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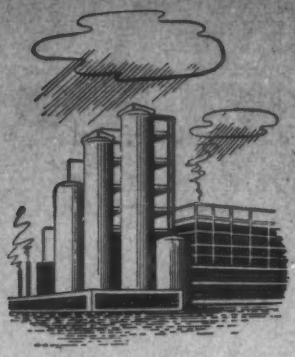

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THE LOOK BOX

ONE of the glib expressions of this day comes usually in these words:

"There is enough for everybody."

All too often it comes as an indictment, wherein there is a charge that some group is withholding material things from another group. The words and similar expressions are accepted as the full justification for communistic practices.

There Can Be Enough

The words do not express all the truth. There are not enough "shoes and ships and sealing wax" for everybody.

It is true, however, that enough of these and other material things can be made for everybody. Want does not exist for lack of raw materials and methods of conversion.

Deficiencies exist because men have not learned how to satisfy their necessities.

Unfortunately there is controversy over solution of the problem. Whatever the approach, men should accept that goods must be made before they can be used. Solution will not come by charging that one group possesses beyond its merits and, therefore, must divide. Enough will not come by division but through multiplication.

NO ONE can listen to even a part of the deliberations of a meeting of the American Chemical Society without coming to the conviction that men are learning how to convert the materials of the earth and its atmosphere to the service of mankind. Already the accomplishments are startling and the possibilities far outstrip accomplishments.

Patent Rights

The status in oil is proof of what lies ahead. For years it has been possible to break oil down by distillation. Only recently have men learned how to put the parts back together after even closer breaking apart. In catalysis and synthesis the oil hydrocarbon becomes a universe, it has so many possibilities.

What science can do with the raw materials at its command seems to have no limit.

The disturbing prospect is the political attitude toward the accomplishments of science. Research comes into a patent if it has value for mankind. For some reason the politician cannot conceive of a patent as property. He is willing for the owner of a patent to erect buildings and install equipment. But the patent, the product which permits the building and its equipment does not hold high favor.

Such terms as "patent pool" and "cartel" cause the political fur to bristle, however smooth it may remain in the presence of the word "property."

The ownership of several patents may be a "patent pool." When men deal in the administration of what patents permit, they may form "cartels." It would be helpful if men in government would reveal how corporations with headquarters in different countries are going to exchange benefits of patent holdings without forming "cartels." Governments form "cartels" when they agree to the apportioning of market territories.

The politician insists upon "free access to patents." Under that requirement there would be little seeking of scientific accomplishments on which to base patents. Neither would there be cause for erecting buildings and installing equipment.

That harmful practices can come out of patent ownership is admitted. Ownership of buildings and equipment may accompany sorry business

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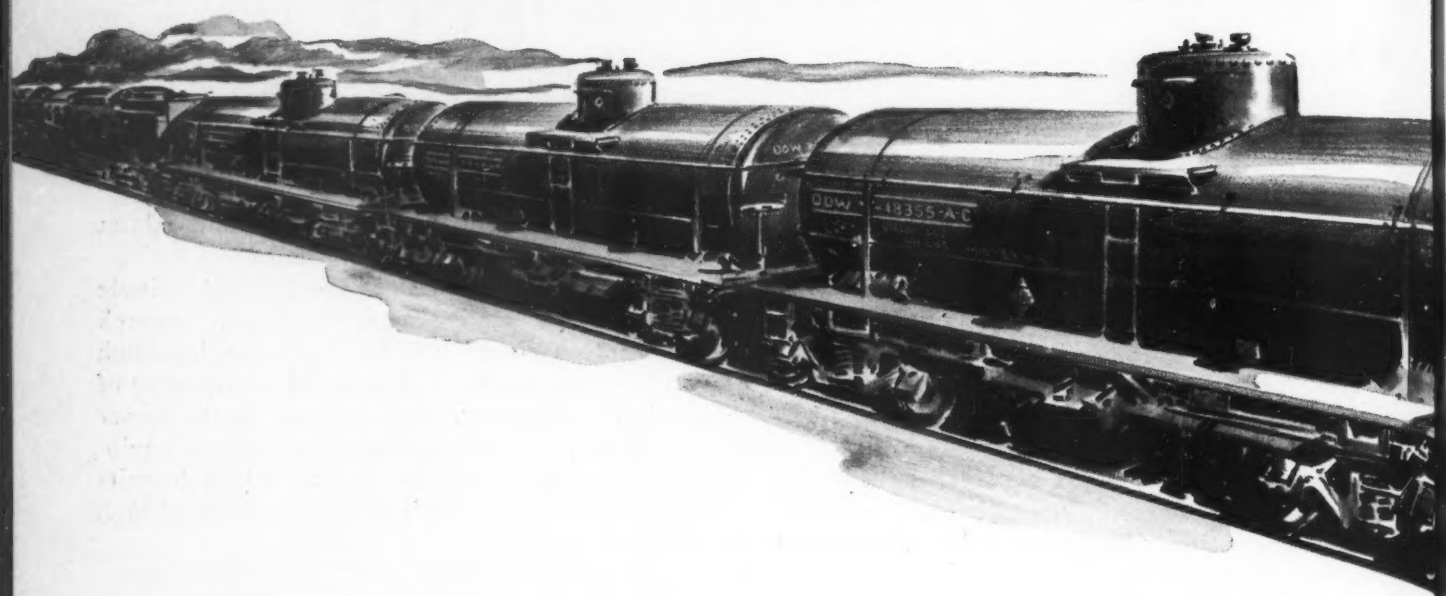

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practice. No one recommends destroying the building in order to restrain the harmful practice. It would be helpful if men would agree also that there is no need for erasing the privilege of patent ownership in order to counteract evils that may accompany ownership.

Synthetic Gasoline

SYNTHETIC liquid fuels are once again under the spotlight. Investigated in Germany in the early part of this century, they first received consideration here around 1925 when failing petroleum reserves spurred oil companies to seek new domestic sources for liquid fuels manufacture. However, synthetics were soon pushed into the background by the discovery in 1931 of East Texas' immense pool of petroleum. Again the specter of inadequate petroleum resources to offset increased demands has focused attention on the possibility of synthetic liquid fuels for the long-range future. To explore this more thoroughly a $30,000,000 program is to be carried out over the next five years by the Bureau of Mines.

Early research in Germany, stemming from the same fundamental work that led to their synthetic ammonia and methanol (wood alcohol) processes, was directed toward the production of a liquid fuel from coal by reaction with hydrogen and from water gas, a coal- or coke-derived mixture of hydrogen and carbon monoxide gases. The ammonia and methanol processes were rapidly adapted to American conditions, but coal liquefaction processes were found economically unsuited to compete with crude petroleum.

The aim of the current program is to develop three approaches to economic commercial processes for production of synthetic liquid fuels equivalent in use to present petroleum fuels. One approach, hydrogenation of coal or coal tars, has already received considerable attention both here and abroad, and today is probably providing Germany with synthetic fuel. It is, however, an expensive operation involving two major steps; the first, the production of a heavy oil, and the second, conversion of the oil to gasoline by the addition of more hydrogen (hydrogenation). Another is synthesis of liquid fuels from water gas, derived from coal, coke, lignite or natural gas, developed by Fischer and Tropsch in Germany and by Myddleton in England. This also is probably in use in Germany today. The third is oil shale processing, now practiced commercially on a small scale in Australia and Scotland. As our oil shale reserves are estimater to be high, this approach is expected to receive special emphasis.

Gasoline produced by high-pressure hydrogenation of bituminous coal has been estimated in testimony before Congressional committees to cost from 16 to 22.6 cents a gallon, compared with 8.5 cents for gasoline made from crude oil selling at $2.00 per barrel, about 75 cents above present prices. However, it was indicated in this testimony that synthesis by the Fischer process, using natural gas, may cost approximately 8.8 to 11 cents a gallon, which is only a fraction higher than the petroleum-derived product.

Oil shale is a rock-like material from which oil may be distilled by heating. It is estimated that United States oil shale might produce some 100 billion barrels of oil, or five times the present estimated petroleum reserves. The oil from the richest shales when processed by standard refinery methods may produce gasoline at a cost of from 9 to 11 cents per gallon compared with from 5 to 7 cents per gallon for gasoline from petroleum. Tar sands, intimate mixtures of tar and sand, are even more abundant in North America, with enormous Canadian deposits estimated to contain from 50 to 250 billion barrels of recoverable oil. Although the Canadian government has sponsored experimental work for the past three years in connection with the Alberta tar sands, too little is known of recovery and processing costs for estimating gasoline costs from this source.

As the pinch of diminishing domestic supplies of crude petroleum begins to be felt, the first recourse of the refiners will probably be to imported oil. As the cost of crude increases, there will be greater incentive to obtain higher yields of gasoline by more elaborate processing, such as hydrogenation, use of by-product gases and so on. Further increases in costs should then permit competitive production of gasoline from oil shale, tar sands, and to some extent from natural gas by water-gas syntheses. On the basis of presently known European costs, processes based on coal would be the last resort in gasoline production. However, the proved reserves of natural gas are but little greater than the proved petroleum reserves, and in the years to come further research and development may improve one of the coal liquefaction processes to the point where it would be competitive with the distillation of oil shale.

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Pan American Petroleum & Transport Company in Chemical & Engineering News.

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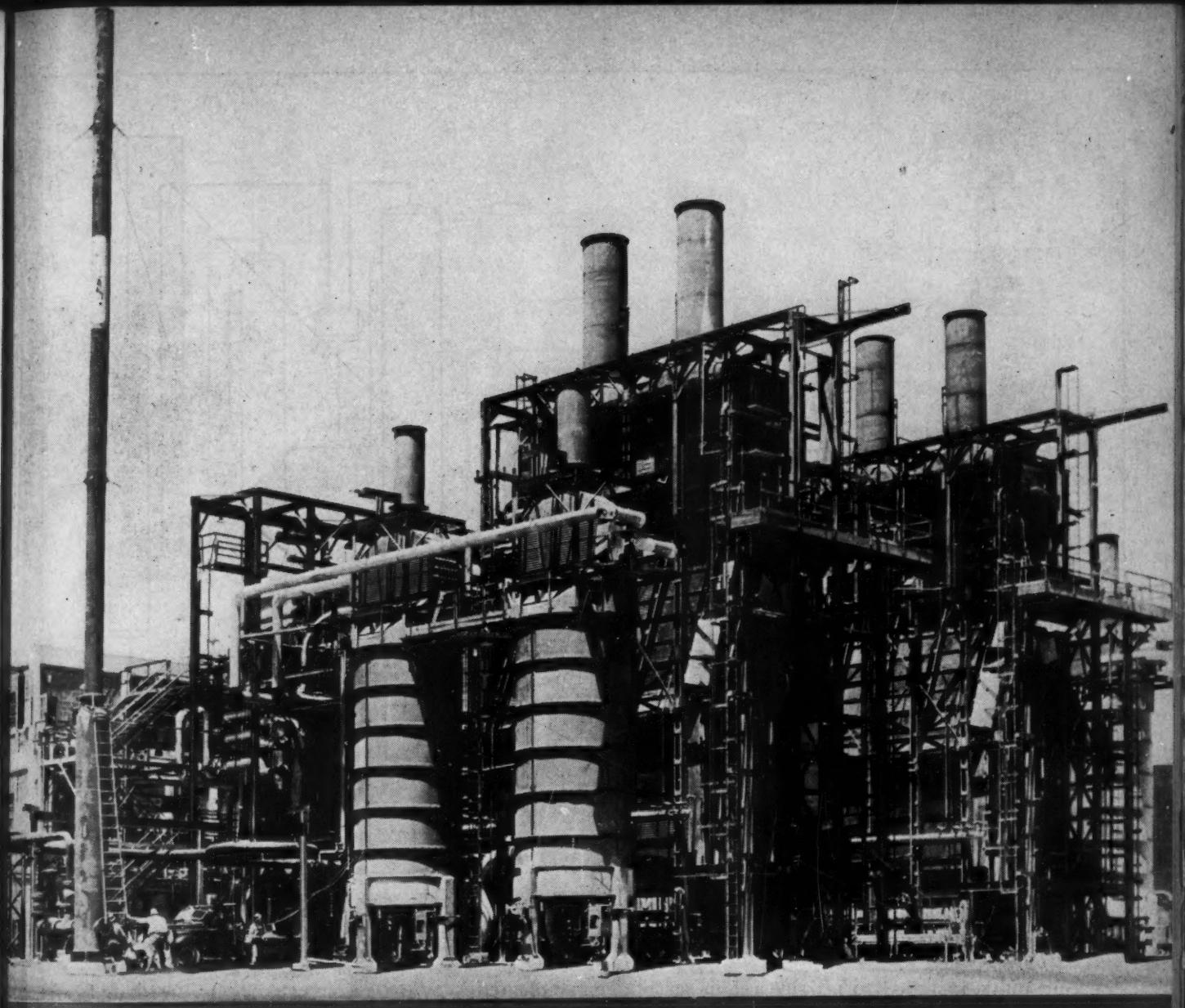

General view of large Cycloversion plant, showing control house, catalyst chambers, furnaces and superheaters

CONVERSION OF THERMAL CRACKING TO THE Cycloversion Process

A. E. BUELL and P. M. WADDILL
Phillips Petroleum Company, Chemical Products Department

THE Cycloversion process, developed by Phillips Petroleum Company, for catalytic cracking and catalytic reforming of petroleum distillate cuts to produce superior-octane-rating motor fuel has been described in two articles[1,2] which have been published recently. The desirability of producing such gasolines by those refiners who must first install appropriate equipment has been open to much discussion within recent months. Increased interest will be shown as the time of converting refineries to peacetime activities approaches, especially if the octane number of house-brand gasoline is to be increased materially. Catalytic cracking certainly represents an excellent means to produce such gasoline from gas oil cuts.

Since many refiners already have large catalytic-

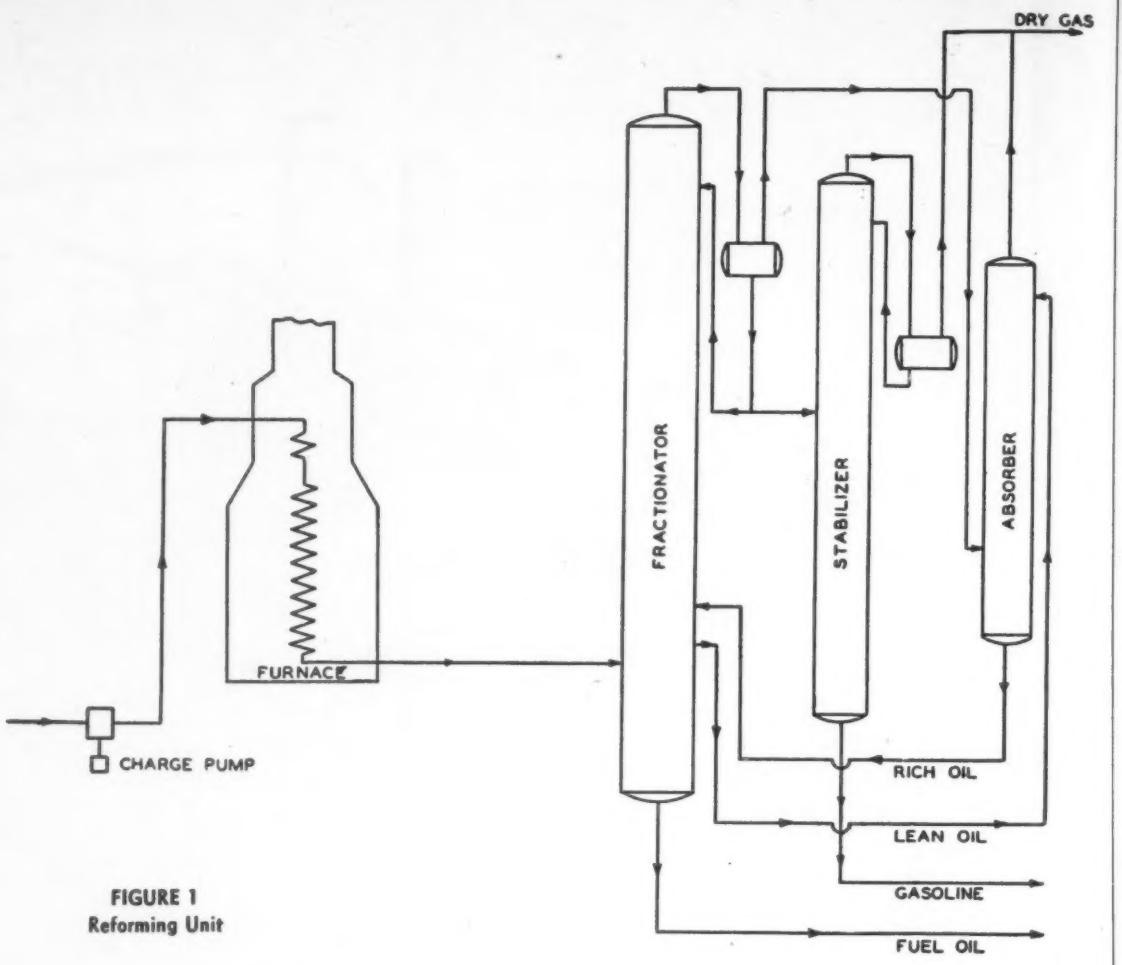

FIGURE 1
Reforming Unit

cracking units, installed to provide requisites of the war effort, their problem will consist mainly of rebalancing their charge stock and corresponding operating conditions. Other refiners who do not have such equipment will be interested in adding catalytic-cracking units or converting present thermal equipment to catalytic units. It is believed that Cycloversion will contribute materially to this phase of post-war operations because of the fundamental simplicity of the process. Its two most important features are: (1) relatively long cycle time (3 to 12 hours), and (2) fixed-bed catalyst chambers. The equipment can be installed, figuratively speaking, between the outlet of a furnace and the inlet of suitable fractionating equipment.

Almost any type of oil-cracking equipment, such as that for gas oil cracking or thermal reforming, can be adapted to Cycloversion. As an example of the complete utilization of existing thermal-cracking equipment, the conversion of a thermal-reforming unit will be described. In many instances, if the refiner had sufficient feed stock available, a 1000-barrel-per-day thermal-reforming unit could easily be converted to a Cycloversion plant of somewhat greater capacity. However, in order to simplify this discussion it is assumed that a refiner has an existing 1000-barrel-per-day, single-pass, thermal reformer, which a study of the plant's economics has indicated should be converted to a 1000-barrel-per-day Cycloversion unit.

Thermal-Reforming Unit

A brief description of the equipment assumed to be in the existing thermal-reforming unit is as follows:

The cold naphtha charge is fed to a typical radiant type furnace by a reciprocating pump. The effluent at 1050° F. and 900 pounds per square inch, gauge, is mixed with cooling oil and passes to a combined hot-oil flash chamber and fractionator operating at 85 pounds per square inch, gauge. Cracked fuel oil is yielded as the kettle product, and gas oil, to be used for cooling oil and absorption oil, is withdrawn from a doughnut tray as a sidestream.

A portion of the overhead is removed as product; the remainder is returned to the column as reflux. Flashed vapors from the overhead accumulator pass to an absorber operating at 60 pounds per square inch, gauge. The rich oil from this absorber is pumped back to the fractionator for stripping. The overhead gasoline is heated and pumped to a stabilizer, operating at 185 pounds per square inch, gauge, where the propane and butane are removed. The feed heat is supplied by exchange with the stabilized product, and the reboil heat is supplied by exchange with the hot cooling oil side draw from the fractionator. The overhead, consisting of pro-

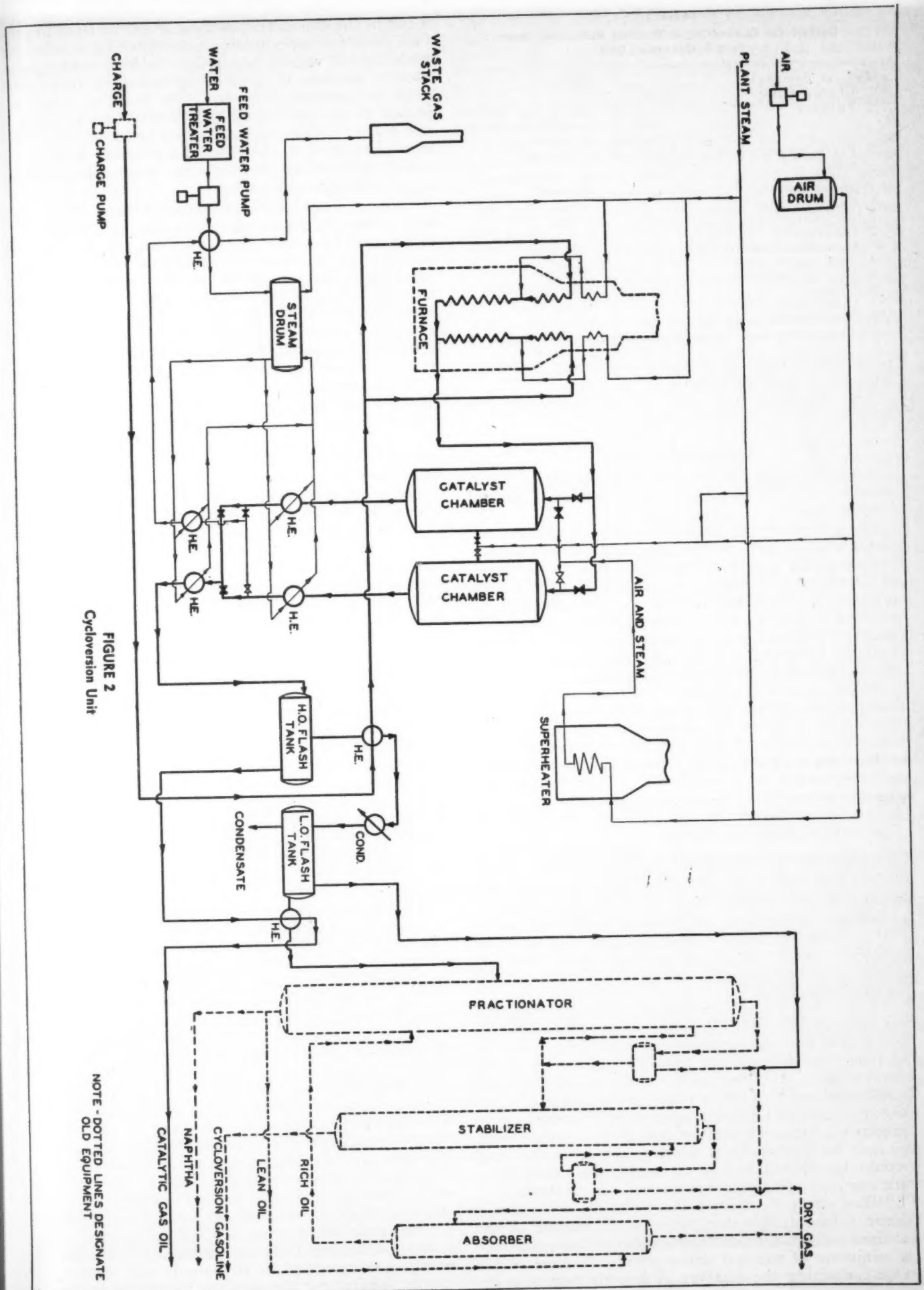

FIGURE 2
Cycloversion Unit

TABLE 1
Outline for Converting a Thermal Reforming Unit to a Cycloversion Unit

a. *Present Equipment*	*Changes*
1. Charge Pump	None
2. Furnace	Rearrange tubes for parallel flow and provide for steam heating and injection.
3. Fractionating Equipment	Small piping changes.
b. *New Equipment*	*Number*
1. Catalyst cases	Two
2. Air compressor	One
3. Superheater (air-steam mixture)	One
4. Feed water pump	One
5. Heat exchangers	Eight
6. Drums (flash tanks, etc.)	Four
7. Instruments, pipe, etc.	

pane and butane, is partially condensed for reflux, with the remainder passing on to fuel.

The simplified flow diagram for the thermal reforming unit is shown in Figure 1.

Cycloversion Unit

After changing the thermal reformer into a Cycloversion unit, the equipment will be used in the following manner.

The gas oil charge is preheated in a waste-heat exchanger and then passes into the furnace. Superheated steam is injected into the coils preceding the high-temperature radiant section of the furnace. The mixture of steam and oil vapors flows through the catalyst chambers where cracking takes place. The chamber effluent passes through a pair of waste-heat exchangers in series and on to conventional distillation and recovery equipment.

While one chamber is on stream the second is being regenerated. This regeneration is effected by passing a mixture of steam and air through the catalyst to burn off the carbonaceous deposit.

The steam produced in the waste-heat exchangers is superheated in a small coil in the furnace and then injected into the oil-vapor lines as mentioned above. A simplified flow diagram for the Cycloversion unit is shown in Figure 2.

Changes Required for Conversion

In Table 1 are listed the changes in existing equipment and new equipment required for conversion.

Charge Pump. Since the reforming unit operates at 900 pounds per square inch, gauge, inlet pressure and 1000-barrel-per-day charge, the charge pump has ample head and capacity for the 1000-barrel-per-day Cycloversion unit.

Furnace and Tubes. The furnace, used in the reforming unit to heat the oil to approximately 1000° F., has ample heating capacity and a sufficient number of 4- to 6-percent chrome tubes for use in the Cycloversion unit. However, as a result of (1) the small inside diameter of the furnace tubes, and (2) the use of steam and a lower operating pressure (outlet pressure approximately 100 pounds per square inch, gauge) in Cycloversion service, the pressure drop would be excessive. Consequently, the connections are rearranged to provide two coils in parallel.

When changing the coil flow, due consideration is given to the design to provide quick heating in the radiant or high-temperature section of the coil, since a minimum of thermal decomposition is desired before contacting the catalyst. A few changes also are made in the convection section of the furnace to provide coils for superheating steam, which is admixed with the oil vapors preceding the high-temperature radiant section. By providing two coils in parallel both the pressure drop from the point of steam injection to the coil outlet, and the absolute pressure at the point of steam injection, are reduced. This permits the use of the 250-pound-per-square-inch steam which is produced in the waste-heat boilers following the catalyst chambers.

Catalyst Chambers. The furnace effluent passes into one or two chambers which contain the Cycloversion catalyst. These chambers are installed as close as possible to the furnace outlet to reduce thermal cracking in the transfer line to a minimum. The carbon-steel shell of each reactor is protected from the high regeneration temperature, and also from corrosion by sulfur compounds, by an internal lining of refractory material. An alloy-steel screen is used in the bottom of the reactor to support the catalyst.

The catalyst chambers for this installation each contain two beds of catalyst, as is indicated by the piping shown entering the sides of the chambers in Figure 2. With some charge stocks, and under other special conditions, a larger number of beds might have been preferred. For a smaller plant, where investment requirements were of prime importance, a single bed might have been used.

Waste Heat Exchangers. Directly beneath, and attached to each catalyst case, is a waste-heat exchanger which cools the catalyst case effluent and produces steam required in the process. These exchangers are also internally lined to protect the shell from the high temperature of the regeneration gases. The gases are cooled sufficiently in these exchangers to permit the use of conventional high-temperature valves and other fittings in the lines. The effluent from the first waste-heat exchanger passes through a second waste-heat exchanger. Here, during the process period, the cracked gas oil is cooled sufficiently to condensate the recycle-oil cut.

Product Recovery. The product from the final exchanger goes to a hot-oil flash tank where the liquid and vapor streams are separated. The steam which is added in the furnace acts as a diluent in this flash drum to help prevent tarry residues from settling out and also helps to flash off the desired vapors. The recycle gas oil is cooled in a waste-heat exchanger before going to storage.

The vapors from the hot-oil flash tank pass through a waste-heat exchanger which serves to preheat the raw feed to the furnace. Following this, the steam and most of the hydrocarbon are condensed in a water-cooled condenser.

The water, liquid hydrocarbon, and vapors are separated in a light-oil flash drum. The liquid, which contains naphtha and unstabilized gasoline, is heated to its bubble point by the recycle gas oil and is then fed to the fractionator. The vapors from the light-oil flash tank pass to an absorber.

In the fractionator the distillate is cut for a 400° F.-end-point gasoline, thus leaving a 525° F.-end-point naphtha as kettle product. A portion of this naphtha is used as absorption oil in the absorber. The fractionator overhead is fed to the stabilizer where propane and butanes are removed to provide gasoline with the desired Reid vapor pressure.

The absorber used in the reforming unit to recover the heavier components from the tail gas formerly was operated at 60 pounds per square inch, gauge. Therefore, the catalyst chambers in the Cy-

cloversion unit are operated at approximately 75 pounds per square inch, gauge, to allow the light gases in the catalyst chamber effluent (vapor stream from the light-oil flash tank) to pass directly to the absorber without recompression. Since a naphtha cut is used for absorption oil, rich oil from the absorber is recycled to the fractionator.

As will be seen by comparison of Figures 1 and 2, only a few minor piping changes are required to adapt the reforming unit fractionating section for use in the Cycloversion unit.

Catalyst. The principal features which make the catalyst used in the Cycloversion process superior to various other catalysts are:

(a) It is not poisoned by steam, sulfur or similar compounds. This permits the use of either steam-air or inert recycle gas-steam mixtures for regeneration.

(b) The catalyst can withstand high reactivation temperatures without any loss in activity.

(c) Mechanically, it is strong and rugged.

(d) Catalyst cost per unit of product will be low since the catalyst cost per pound is low and the service life is relatively long.

Catalyst Regeneration. To provide the air-steam mixture necessary for regeneration of the catalyst, an air compressor and small superheater must be installed. A mixture of compressed air (at 90 pounds per square inch, gauge) and plant steam is fed to the regeneration furnace where it is heated to approximately 1050° F. This furnace is designed specifically for very low pressure drop by using a special circular construction with alloy tubes. The air-steam ratio and the superheater outlet temperature are controlled to provide a regeneration temperature of approximately 1400° F.

After passing through the catalyst chamber and through two waste-heat exchangers which generate process steam, an additional quantity of heat is recovered from the regeneration gases in a feed-water heater, before they are vented through a waste gas stack.

Cycle Time. In this example a six-hour cycle has been assumed; i.e., each chamber is on process for three hours and on regeneration for three hours. A portion of the regeneration time is required for valve switching, purging, and adjusting flow rates. Since the process (and regeneration) periods are long, no automatic cycle-timing or valve-switching equipment is required.

When using hand-operated valves, the time required to switch the chambers from process to regeneration ranges from 5 to 10 minutes. This gives ample time for necessary steam purging to remove hydrocarbons before any air enters the chamber. The oil vapors purged from the chamber pass along with the regular chamber effluent stream to the recovery system and are thus saved.

Steam Supply. The major portion of the steam required for the catalytic section of the Cycloversion unit is produced in the waste-heat exchangers which follow the catalyst chambers. One 250-pound-per-square-inch, gauge, steam drum is provided as a common water circulating surge for all the waste heat exchangers. A small quantity of 125 pound-per-square-inch, gauge, makeup steam is required from the refinery supply.

The fractionators used in the Cycloversion operation will require approximately the same quantity of heat that they did during the original reforming operation.

Economics

From an economic standpoint the Cycloversion process possesses numerous advantages. Among these are: low investment cost, ease and simplicity of operation, and low operating cost. In addition, the feed stock and product characteristics may be varied over a considerable range.

For these reasons this process should be given careful consideration by those refiners interested in converting thermal-cracking units to catalytic-cracking units, as well as by those who may wish to construct completely new catalytic-cracking equipment.

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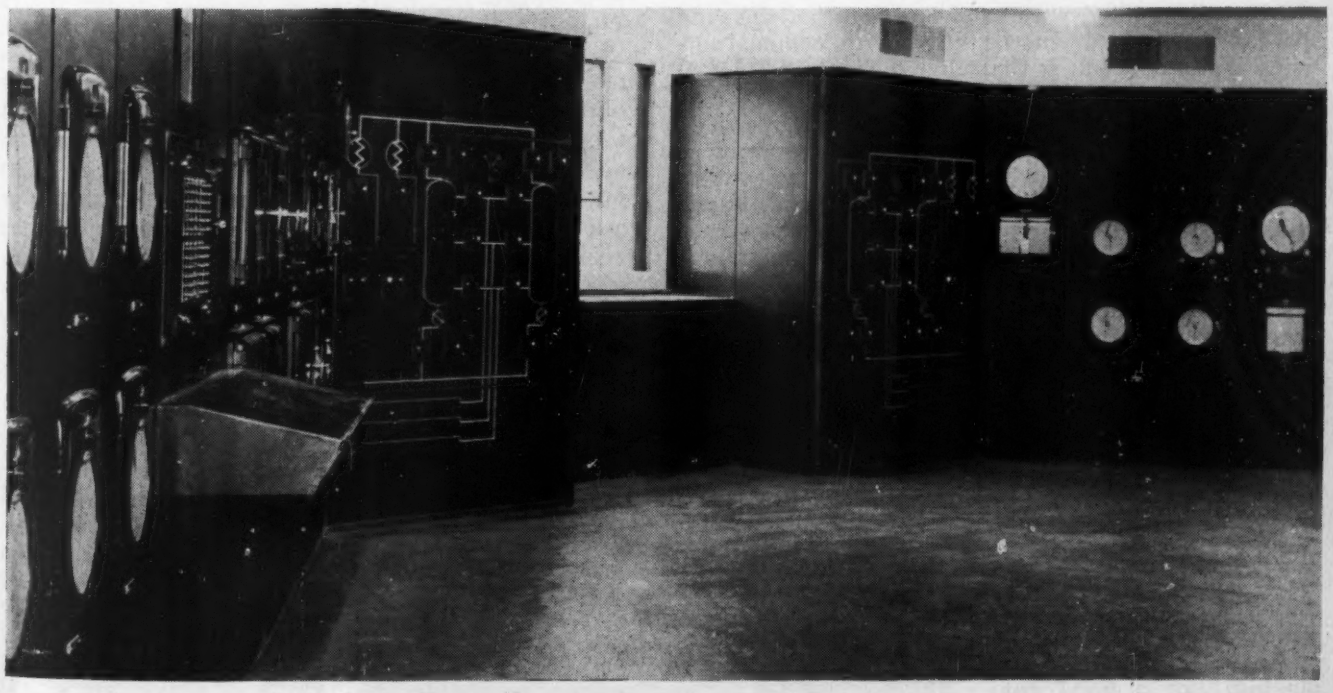
[1] Schulze, Walter A., and Helmers, C. J., Oil and Gas Journal, 42 No. 49, 225 (1944).

[2] Arnold, P. M., and Skinner, Bradley, World Petroleum, Annual Refinery Issue, 142 (1944).



Control room in large Cycloversion plant

How to Determine the Amount of Concrete Needed

E. N. KEMLER
Professor of Mechanical Engineering, Purdue University

FIGURE 1 on the opposite page, gives in compact form a ready means of estimating the amount of concrete needed and also the materials which need to be supplied for a given amount of concrete.

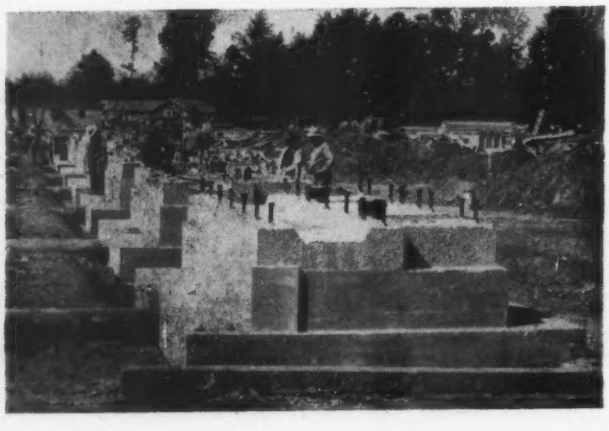
In making up the chart shown in Figure 1, the values have been based on requirement for a 1-2-4 mix which is commonly used for foundations, reinforced floors, footings, etc. For this 1-2-4 mix approximately .22 times the volume of section in cubic feet sacks of cement are needed. The amount of sand in cubic feet is approximately two times the number of sacks of cement and the amount of gravel in cubic feet is two times the cubic feet of sand. The cubic yards of sand will be approximately 1/60 the volume of the foundation in cubic feet and the amount of coarse gravel or rock will be twice the amount of sand.

In a 1-2½-5 mix the number of sacks of cement will require approximately .18 times the cubic feet to be filled in cubic feet. The amount of sand in cubic feet will be approximately 2½ times the number of sacks and the amount of gravel in cubic feet will be approximately two times the amount of sand.

Considerably more than one cubic foot of materials must be used to give a cubic foot of concrete, inasmuch as some of the large pore spaces or voids in the gravel will be filled with sand and some of the void spaces of the sand will be filled with cement particles. The net result is that almost 1½ cubic foot of individual material is required to make one cubic foot of final concrete.

In cases where precise specifications are required or careful control is involved the measurement of the quantities on a weight basis must be used. Variations in porosity of different types of gravel or rock may considerably affect the mix which is obtained. If handled on a weight basis the final mix will in general be much more uniform.

In mixing and placing concrete the amount of water should be kept to a minimum. The strength decreases as the amount of water is increased. The amount of water used is therefore largely determined by the minimum which can be used for best mixing, handling, and placing. For a good concrete job care must be taken to tamp the mixture in place, to eliminate any air pockets, to keep the freshly poured concrete surface moist or prevent drying out, to keep the temperature up in cold weather, and to place the concrete in such a way as to prevent segregation of the coarse and fine particles. These precautions are necessary since the formation of concrete is a chemical and not a drying out process. The setting time of concrete can be to some extent controlled by the use of various expediters. The use of very fine cement will give a quicker setting cement. Also the use of chemical such as calcium chloride will likewise speed up the setting of the concrete.



Use of the chart for the determination of the amount of sand, rocks and cement needed for a given foundation can best be shown by an example. If the concrete block as shown in Figure 1A is used as an example, the determination of materials needed can be determined from the following procedure. It is first necessary to divide any complicated block into its element, usually into rectangular sections. In the cases of a triangular shaped section the volume can be found by taking half of volume of a complete rectangular section.

The solution for the simple block shown in Figure 1A is shown in Figure 1. By entering at the upper lefthand corner at a width of 6 feet, tracing down to a length of 10 feet and then across to a thickness of 3 feet. By tracing up to the upper scale gives the volume of the block as 180 cubic feet. The amount of materials for a 1-2-4 mix are as shown on the various scales. The cubic feet of sand for 180 cubic feet of concrete are 80, the cubic feet of gravel or rock 160 cubic feet and about 40 sacks of cement are necessary. To these values must be added any losses through handling or mixing processes. When the volume is known the amount of materials necessary can be found by tracing down from the volume of the section in cubic feet. The amount of sand and gravel in cubic yards can be found by tracing on down to the scales below the amount of cement. For the above example 3 cubic yards of sand and 6 cubic yards of gravel are necessary.

FIG. 1 A

FIGURE 1

PART 1

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PREPARATION of the handbook, "Principles and Practice of Flow Meter Engineering," involved collection of a great amount of data, much of which could not be included in a book designed to be used for quick reference. The accompanying text has been written to present the most important material omitted from that work.

The first installment is confined to a qualitative discussion of The Characteristics of the Differential Type Flow Meter and its Various Primary Devices.

The second installment covers quantitative data on The Results of Conditions Affecting the Operation of the Differential Type Flow Meter.

The third installment discusses The Installation of the Differential Type Flow Meter, and describes the solution of a number of typical flow problems.

The second and third installments will appear in succeeding issues.

Characteristics of the Differential Type Flow Meter and Conditions Affecting Its Operation

ONE of the features which makes the differential-type meter so important in the present-day industrial scheme is its adaptability to control. Many of the modern process developments would be extremely difficult, if not impossible, without some means of maintaining a continuously uniform rate of flow. The differential-type meter being essentially a rate-measuring device adapts itself perfectly to continuous processes.

There are, of course, batch operations in which it is satisfactory to cut off the flow after a certain predetermined quantity has passed the meter. There are also operations in which it is satisfactory to dump in a certain predetermined quantity of a secondary material after a predetermined quantity of the primary material has passed the meter, but many industrial processes demand continuous balanced operation. Non-uniform flows would upset other control instruments on the unit.

In addition to its adaptability to control, the differential-type meter has many other excellent characteristics. High among these is its flexibility. The same instrument may be used on almost any type of flowing liquid at almost any operating temperature. Its capacity may be changed on a moment's notice by a change in the differential producer or primary device. The same instrument may be used on a wide range of pressures.

Another useful characteristic is its adaptability to corrosive or dirty fluids. The flowing material does not pass through the measuring mechanism and may be easily sealed, purged or otherwise prevented from entering the meter mechanism.

Because there is no movement in the instrument unless there is a change in rate of flow, and because of freedom from friction and inertia effects, the differential-type meter almost never wears out.

Many flow meters not equipped with automatic control mechanism are used as a guide for hand control. Any instrument whose readings are used to

THE orifice-meter manufacturer who keeps records has the equivalent of a laboratory staff employing personnel numbering in the thousands. Each of the installations is a check test on which any discrepancy in measurement or technical difficulty is sure to be reported. Errors in basic data do not exist for long before a flood of reports brings about a correction, and unsound applications are soon weeded out as a matter of economic necessity.

Examples of changes occasioned by reports from the field are to be found in the data used for correcting for tap locations, method of calculating supercompressibility corrections on hydrogen, and flow corrections for viscous oils. Similar reports have taught manufacturers to question measurement adajacent to the discharge of reciprocating gas compressors, liquid-gas mixtures of non-uniform consistency, and intermittent flows of short duration.

Manufacturers' records cover a variety of services impossible to duplicate in the laboratory. Taken at random from the files is the following cross-section on which the differential type meter has been used successfully:

Acetaldehyde
Acetic Acid Vapor
Acetone
Acetylene
Amines
Anhydrous Ammonia (gas and liquid)
Aqueous Ammonia
Asphalt
Beer Feed
Benzol
Black Liquor
Black Oil
Butadiene
Butane (gas and liquid)
Carbon Dioxide
Caustic
Chlorine (gas and liquid)
Coke Plant Light Oil
Coal Tar
Crude Oil
Crude Tar
Diesel Oil
Di-Ethylene Glycol
Doctor Solution
Dowtherm
Edeleanu Extract
Ethyl Acetate
Ethyl Alcohol
Ethylene (gas and liquid)
Fatty Acid
Furfural
Hydrogen
Hydrogen Sulfide
Iso-Octane Distillate
Kerosene Distillate
Lead Sulfide in Caustic
Lime Slurry
Magensium Sulfate Solution
Mercapsol
Methanol Vapor
Methylene Chloride
Naphtha
Natural Gas
Nitro Benzene
Nitrogen
Oleum
Oxygen
Phenol
Pressure Distillate
Propane (gas and liquid)
Raffinate
Sea Water
Steam
Styrene
Sulfur Dioxide
Sulfurous Acid
Sulphuric Acid
Toluol
Trimethylene Dibromide
Vegetable Oil
Water
Wax and Solvent Mixture

The above list represents only a small fraction of the file.

guide an operator in manipulating a throttling valve or regulating the speed of a pump is essentially an implement of control.

A well-balanced study of the subject of flow-meter engineering requires that this type of application be distinguished from that involving purchase, sale or accounting. On control service, consistent measurement is essential; absolute accuracy is secondary. For instance, for most control purposes, a meter which

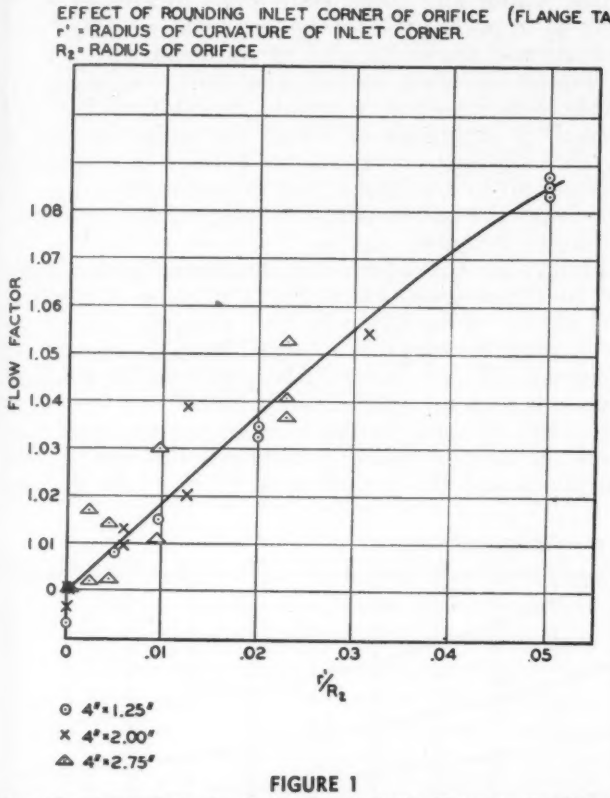

FIGURE 1

From "Developments in the Application of Orifice Meters to the Measurement of Fluids, Especially Gases," by Howard S. Bean, Pennsylvania State College Bulletin No. 20.
NOTE: A high flow factor indicates a low meter reading.

was consistently 4 percent high would be much better than one which varied over a range of ± 2 percent.

We can cite one case in which, due to the unpredictable nature of the measured fluid, measurements were found to be approximately 40 percent high and yet the user was more than pleased with the results. It could not have been more satisfactory if the readings had been exact, because by mere adjustment of the control point he obtained the desired results. An instrument which varied from a + 20 percent error to a —20 percent error would have been worthless. As a basis of purchase, sale, or accounting, however, the instrument with the 40 percent error would be next to worthless.

This does not mean that the differential-type meter is not an accurate measuring device. Nevertheless, qualifications of consistent operation outweigh its qualifications of accuracy. Under most conditions, if it be in error, the error will be constant throughout the meter's operation.

This should not be interpreted as a plea for careless installation on control applications. In most cases, a better measuring installation gives better control. On the other hand, no control installation should be given up just because the space available or other factors are such that it is impossible to meet the letter of the rules for flow-meter installation. In the iron foundry, blast-pipe sizes usually are large and the blowers often are almost bumped right up against the cupola. Straight runs of pipe are notoriously scarce. Some of the most valuable installations have been made possible only by variations in the form of primary device and proper use of straightening vanes, where only a few scant pipe diameters were available for the installation of a primary device.

Constant Errors and Variable Errors

While it is impossible to draw a definite line between the conditions which produce constant errors and those which produce variable errors, an attempt at classification should be helpful.

Among the sources of constant errors would be those due to bore of the primary device, contour of the primary device, dullness, thickness, eccentricity, concave or convex upstream face of plate and errors in the diameter of the pipe. Also, errors in the installation of the flange, excessive recess between the end of the pipe and the face of the plate and roughness of the pipe at points not adjacent to the pressure taps should result in constant or nearly constant errors.

Burrs or irregularities of the pipe adjacent to the pressure taps would be classified under border-line cases or sources of semi-constant errors. Particularly in the event of disturbed flows these would be a cause of a slightly variable error. The effect of incorrect tap location or pressure taps which were too large could be classified as a semi-constant error if the location is at a point where the pressure is changing rapidly. Gaskets cut or installed in such way that they project inside the conduit may be the source of a slightly variable error.

The errors or corrections due to locating the primary device too near the entrance or exit of a conduit ordinarily are constant. However, wind or air currents may result in a variable error. The effects due to various stationary sources of disturbance located upstream from the orifice would be classified as semi-constant as shown by the accompanying extracts from the data of the American Gas Association. In these tables (Table 1), variation in the coefficient ratio, K_c/K_r, represents a variation in error.

The runs in each group were made at differentials varying over a range of about 3 or 4 to 1.

The reader should be warned not to attempt to make corrections or to draw conclusions beyond the statements made herein from the very limited cross section of data in Table 1.

It will be noticed that straightening vanes, if solidly positioned too close to the primary device, result in a constant error. In the case of swages, restrictions, or combinations of elbows in two planes ahead of the orifice, in all cases the variation in error is less than the amount of the error.

The following are sources of variable error, to be

TABLE 1

Effects of 3-Angle 2-Plane Disturbance			Effects of 4x8 Swage at 2½ Dia. Upstream		Effects of 1x6 Vanes at ½ Dia. Upstream		
Run	K_c/K_r		Run	K_c/K_r	Run	K_c/K_r	
426	1.059	Disturbance	775	1.044	454	1.106	With 2-Angle
427	1.059	at 4¼	776	1.044	455	1.109	1-Plane
428	1.059	Diameter	777	1.043	456	1.108	Disturbance at
429	1.059	Upstream	778	1.040	457	1.111	4½ Diameters Upstream
213	1.035		.....		360	1.101	With 3-Angle
214	1.042		.....		361	1.101	2-Plane
215	1.036	Disturbance	.....		362	1.101	Distrubance at
216	1.047	at 14⅝	.....		363	1.102	4¼ Diameters
217	1.046	Upstream	.....				Upstream
218	1.036		.....				
219	1.035		.....				

carefully avoided or minimized in all control installations. The worst of these is pulsation, which is particularly unpredictable if the pulsation cycle is variable as in the case of pulsation produced by a number of compressors operating out of synchronism. On non-compressible fluids it may be minimized by the use of cushion chambers in the flow line between the source of pulsation and the primary device. On compressible fluids it may be minimized by the use of high operating differentials, high ratios of orifice to pipe diameter, or the use of combinations of capacity and resistance in the flow conduit between the source of pulsation and the primary device.

The disturbance produced by a throttling valve of variable opening upstream from the primary device is a source of variable error. It may be eliminated by the use of a straightening vane between the valve and the primary device or by installing the valve downstream.

The progressive building up of dirt or sediment on the primary device is a source of variable error. The thin-plate sharp-edged orifice is more seriously affected than the flow nozzle or Venturi tube. The streamlined entrances of the latter primary devices eliminate upstream pockets where the sediment would drop out, and the scouring action of the high-velocity fluid keeps the foreign material in suspension. The first effect of the accumulation of dirt on a sharp-edged orifice is usually a stream-lined entrance approaching the contour of a flow nozzle. This decreases the jet contraction, and reduces the resistance of the orifice to flow.

The accumulation of gas or vapor in the top of a horizontal pipe on liquid flow or the accumulation of liquid in the bottom of a horizontal pipe on gas flow will cause an increase in the velocity of approach of the flowing fluid and result in a low-reading meter. Here again the flow nozzle or Venturi tube is preferable because of the sweeping action of the flowing fluid. Eccentric or segmental orifices often are installed in such a way as to provide the foreign material a free passage through the orifice. Installation of the concentric orifice in a vertical line with the flow in a direction such that velocity assists gravity or buoyancy in carrying the foreign material through the orifice is preferable if such location can be found.

Gas or vapor in liquid- or steam-meter piping and condensates in gas-meter piping produce erratic results. Vapor and condensate traps located in such a way as to pocket the foreign material where it will not interrupt the continuity of the fluid with which the piping is filled provides a fairly satisfactory remedy but involves a certain amount of maintenance. It is preferable to install the piping in such a way that the gas or vapors are carried out into the flow conduit by buoyancy, and on gas meters in such a way that the condensates are carried into the flow conduit by gravity.

Changes in the operating conditions from those used in the original calculations may be a troublesome source of variation in flow control. The effect of viscosity, although it is possible to correct for it mathematically, is particularly troublesome because it depends both on viscosity and rate of flow. On flow control one of these variables is eliminated. For that reason, in case of a choice between the use of two controllers and the use of ratio control, the former usually is preferable if viscosity corrections are appreciable. Viscosity effects may be minimized by the use of a Venturi tube or flow nozzle as a primary device or by the use of low ratios of orifice to pipe diameter. A primary device especially designed to give a flat coefficient characteristic over a wide range of viscosities may be practical under ideal flowing conditions. Under dirty, erosive or corrosive flowing conditions, the value of this type of primary device is questionable.

It is possible to correct for pressure on compressi-

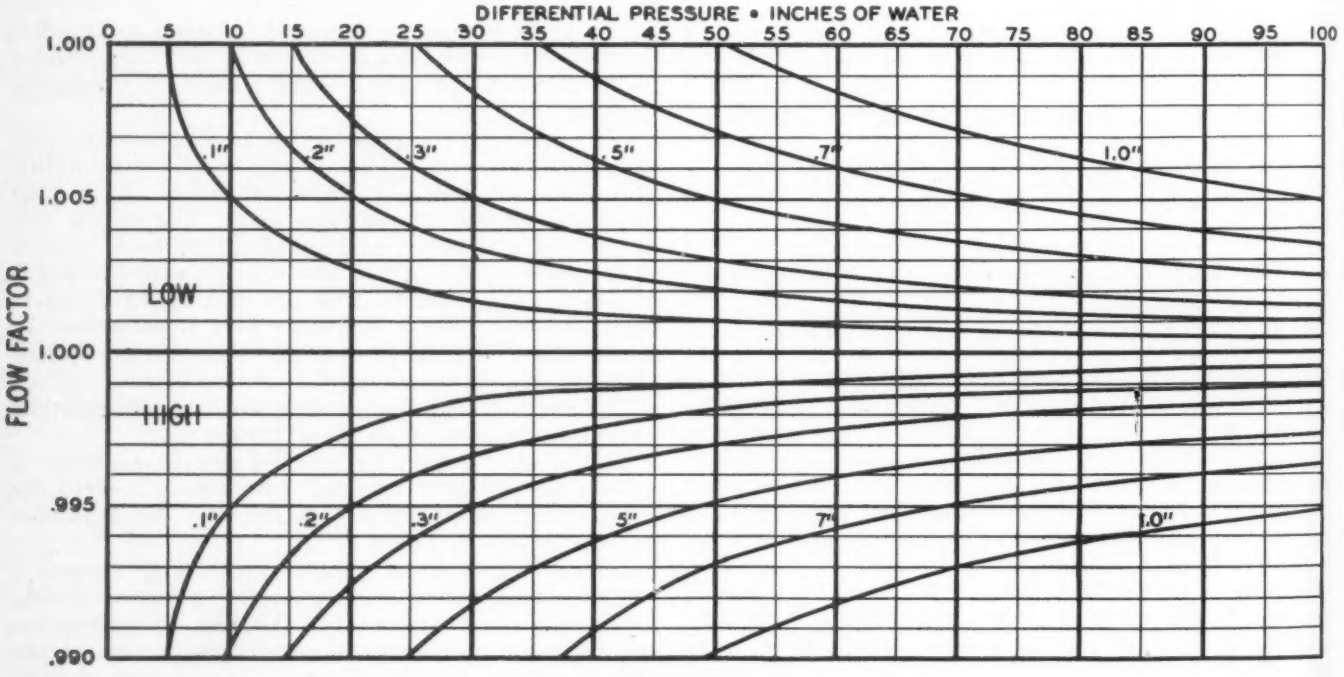

FIGURE 2

Effect of error in differential readings

From "Practical Application of A.G.A. Gas Measurement Committee Report No. 2," by J. E. Overbeck, Series 39, No. 7—III, January, 1939, West Virginia University Bulletin. NOTE: A high flow factor indicates a low gas meter reading, and vice versa.

ble fluids and for density and temperature in controlling the flow of both compressible and noncompressible fluids. If these factors are constant, correction may be made in the primary device or in the range of the instrument. If they are variable, they must either be neglected, or the operator must correct for them manually by adjustment of the apparent rate of flow, or the instrument must be designed to correct for the variations automatically. The latter alternative involves a more complicated mechanism, which

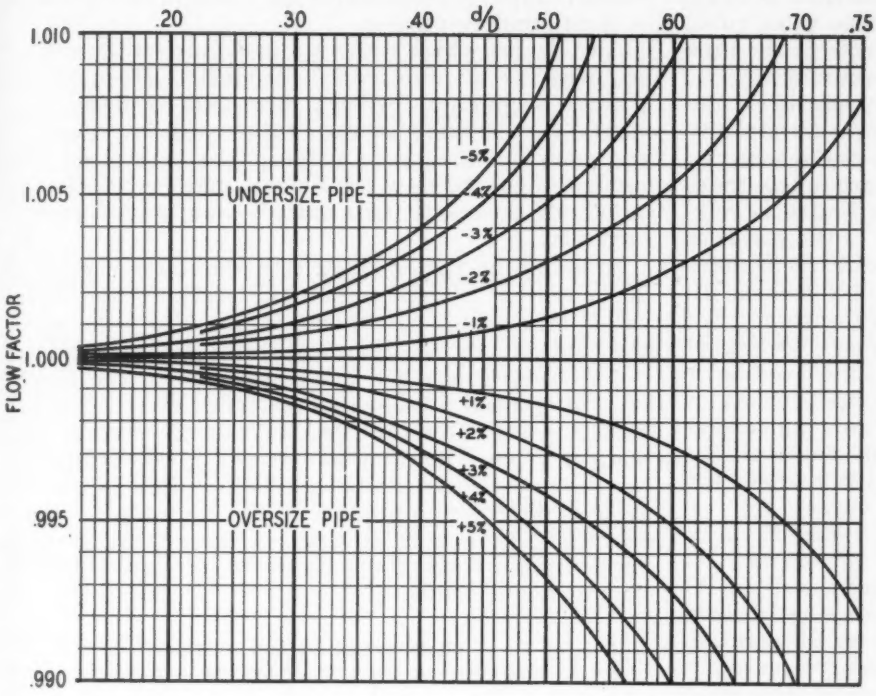

FIGURE 3

Effect of error in pipe run size (based on eight-inch pipe run)

From "Practical Application of A.G.A. Gas Measurement Committee Report No. 2, by J. E. Overbeck, Series 39, No. 7—III, January, 1939, West Virginia University Bulletin.

NOTE: A high flow factor indicates a low meter reading, and vice versa.

often is not justified from the standpoint of initial cost and maintenance.

On measurement for purchase, sale, or accounting purposes, corrections for pressure are easily made from the chart record.

An incorrect zero results in a constant error for flow control but a variable error for flow measurement or ratio control.

Nonuniform calibration characteristics in the instrument also result in a constant error at any one setting for flow control but a variable error for flow measurement or ratio control.

Value of Using Low Ratio of Orifice to Pipe Diameter

No discussion of this subject would be complete without mention of the advantages to be obtained by the use of low ratios of orifice to pipe diameter. Inasmuch as, for the allowable differential, the ratio of orifice diameter to pipe diameter is more or less determined by the size of pipe in which the installation is made, low ratios can only be attained by installing the primary device in a large diameter pipe.

There are only a few isolated characteristics for which a high ratio is desirable. The amount of pressure loss is appreciably reduced (if flange or vena contracta taps are used) by the use of a high ratio. Also a high ratio results in a smaller error due to pulsation in gas flows.

But in other respects a low ratio of orifice to pipe diameter is to be desired. Because of the low velocity of approach, the effects of the line diameter and the accumulation of scum or sediment on the wall of the pipe are reduced. For the same reason, errors due to disturbances upstream from the primary device are minimized. Corrections due to viscosity are lower, errors due to flange recess, pressure-tap location and tap diameter, burrs and obstructions adjacent to the pressure-tap holes and concentricity: all of these effects are minimized.

Limitations of Differential Type Meters

Not all of the characteristics of the differential-type meter are good. Its simplest form, the square-root-flow-scale type, is notoriously lacking in rangeability. Attempts to date to overcome this handicap have resulted in a more complicated mechanism and usually in a loss in consistency of operation. Lack of rangeability is not a handicap in most industrial processes, since these processes are designed to operate at reasonably constant flows.

The differential-type meter is not adapted to intermittent or to reversing flows, such as might occur on a leaky pump. Fluctuating flows may be handled satisfactorily by damping the meter mechanism mechanically, provided the fluctuations do not exceed ±40 percent of the average differential. In such cases, the error due to damping will seldom exceed 2 percent, usually not more than 1 percent. Examples of a 40-percent fluctuation would be differentials ranging from 60 to 140 inches or from 30 to 70 inches. As the percentage of fluctuation decreases, the probable error decreases, and when the amount of fluctuation exceeds the above-mentioned limits, the amount of error increases rapidly. Undamped meter readings should not be taken as an estimate of the amount of actual differential fluctuation, since even an undamped meter contains a certain amount of natural damping.

The differential-type meter is not suited to the measurement of extremely low flows, especially if the flowing fluid is dirty. Small-bore differential producers are difficult to reproduce and should be individually calibrated. If the flowing fluid contains foreign matter, the resistance of the differential producer will be affected quickly.

Accurate coefficients are available for the differential-type meter on slightly or moderately viscous flows. On extremely viscous flows, this type of meter is not ordinarily recommended.

Characteristics of Various Primary Devices

Some types of meters will measure highly viscous flows with satisfactory accuracy. It should be pointed out, however, that many meters which were thought to be immune to the effects of viscosity are found to be seriously affected by it. The choice of a meter for

such flows should be based upon actual experimental data rather than a casual analysis.

The choice of a differential producer or primary device should be based upon operating requirements and economic considerations. Contrary to a widespread misbelief, the thin-plate, sharp-edged orifice is the most accurate of all commonly used cemmercial primary devices when operated without individual calibration, provided it is used on fluids and operating conditions to which it is adapted. In limiting the classification to commonly used commercial devices, we exclude the well-designed laboratory pitot tube, which, if used to make a velocity traverse of the pipe or conduit, is capable of laboratory accuracy.

The thin-plate, sharp-edged orifice has been the subject of more published research work than any other type of primary device. Perhaps one reason for this is its ease of reproduction. There are no contours to match, the thickness, up to certain limits, is relatively unimportant, and the condition of the pressure taps is less important than is the case with primary devices in which the high-velocity fluid comes directly in contact with the pressure-tap opening. For nonviscous homogeneous liquids or gases flowing at low velocities, the thin-plate, sharp-edged orifice is outstandingly superior, as long as pumping costs or pressure losses are not factors. On fluids containing solid matter, however, the upstream edge of the orifice quickly builds up a deposit which changes the resistance to flow and destroys the accuracy.

On clean fluids, a well-designed pitot tube is an extremely accurate velocity-measuring device. Its limitation for commercial use is chiefly due to its inflexibility. At the existing velocity in a certain sized pipe it is capable of producing only one differential, and that often is too low for measurement on available commercial instruments. A further limitation lies in its characteristic of measuring spot velocities. The ratio of the average velocity to the velocity at the point where the pitot tube is located may vary with the rate of flow, disturbances in the flow conduit, the viscosity of the flowing liquid, and other factors. The pitot tube is useless on dirty fluids.

The flow nozzle is useful on high velocities as well as on fluids containing sediment which would settle on the face of an orifice plate. Due to its streamline approach, it tends to carry sediment through the throat rather than permitting it to deposit on the upstream side. Unless there are economic or process reasons why a high velocity is necessary, the high velocity may be reduced by the use of a larger diameter meter run. In such cases, the choice between a flow nozzle in the existing run or an orifice plate in a larger run may be based upon economic considerations. There is very little difference in the pressure recovery of a flow nozzle and a thin-plate, square-edged orifice plate designed for the same rate of flow at the same differential.

The Venturi tube has all of the qualifications of the flow nozzle with the additional advantage of a high-pressure recovery. It also avoids turbulent eddies and dead spaces in the outlet section.

On low pressures where measuring losses account for a large portion of the pumping head, the savings in pumping costs may cancel the extra cost of a primary device of this type in a short time. On a slurry or other material containing a large percentage of heavy solids, this type of primary device may be essential.

The piezometer ring, which is a necessity for accurate measurement with the Venturi tube, may prove a handicap to consistent operation on sediment-bearing fluids. It has frequently been found advisable to eliminate the piezometer rings and provide single pressure taps through which the foreign matter could be continuously purged.

Any device which creates a resistance to flow may be used as a differential producer. Rectangular orifices, segmental orifices, eccentric orifices, segmental or eccentric Venturi tubes and flow nozzles, and even modified gate valves have been used. On some of these the flow coefficients may be calculated; on others, the coefficients must be determined experimentally.

It should be remembered that the differential producer may be chosen to suit the service. The differential measuring instrument is universal; the same mechanism may be used with any of these devices.

The following check list may assist in the choice of a differential producer or primary device. This list is selected to show the need for various types of primary devices. The predominance of good ratings for any one type does not mean that it is a better all around differential producer. The thin-plate orifice outranks all others in its qualifications for the average application involving measurement of relatively clean homogeneous fluids.

Check List of Primary Devices

	Venturi	Nozzle	Pitot	Eccentric or Segmental Orifice	Concentric Orifice
Accuracy and amount of empirical calibration data	G	G	#	P	E
Reliability on dirty service	E	G	VP	F	P
High pressure recovery	G	P	E	P	P
Suitability for viscous flows	G	G	±	U	F
Suitability for high velocities	G	G	G	F	P
Suitability for low velocities	P	P	VP	G	G
Convenience of installation	P	F	E	G	G
Minimum interruption of service during installation	P	F	E	G	G
Low cost (large sizes)	P	F	E	G	G
Low cost (small sizes)	P	F	G	G	E
Suitability for liquids containing traces of vapors	E	G	F	E	*
Suitability for gases containing traces of condensate	E	G	F	E	§
Ease of changing capacity	P	F	VP	G	E

E Excellent
G Good
F Fair
P Poor
U Unknown
VP Very Poor

For measuring velocity at one point in the conduit, the well designed and constructed pitot tube is reliable without individual calibration. For measuring the total flow through a conduit, a velocity traverse is necessary to obtain an accuracy comparable with that of the other primary devices.

± Requires a velocity traverse of the conduit.

* Excellent if the flow is in an upward direction through a vertical conduit.

§ Excellent if the flow is in a downward direction through a vertical conduit.

NOTE: The above ratings are, of course, subject to amendment under special operating conditions. Correct choice of the best primary device can only be made by an experienced flow meter engineer after a careful balance has been made of all of the factors affecting the choice.

Cooling-Water Systems and Their Chemical Treatment

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AMONG its many industrial uses, water for cooling purposes occupies a leading role. In the power plant, the oil and gas industries, in air conditioning and refrigerating equipment, vast quantities of water are used. Millions of dollars are spent for cleaning, maintenance and replacement of condensers, heat exchangers, engine jackets, piping and other equipment.

The problems encountered in cooling-water systems are scale formation, corrosion and biological fouling. A better understanding of the causes of these problems as well as the corrective methods required will be possible with a brief discussion of the more important types of cooling-water systems.

Cooling water systems can be classed in the following manner:

1. Once-through systems.
2. Open circulating systems.
3. Closed circulating systems.

Once-Through Systems

The once-through system as the name implies is one in which the water is passed through the heat-exchange equipment where it absorbs heat and as a result has its temperature increased and is then discharged to waste. The once-through system generally is used only where there is available an abundant inexpensive source of water, at a suitable temperature, such as water from wells, rivers, lakes and other surface supplies where the cost involved is that of pumping only. In this type system no evaporation takes place and the water merely undergoes an increase in temperature. In the absence of evaporation, the water does not concentrate and therefore the circulating water characteristics are substantially the same as the make-up water.

The type scale encountered in a once-through system is almost invariably chiefly calcium carbonate formed from the decomposition of calcium bicarbonate, in accordance with the following reaction:

(1) $Ca(HCO_3)_2$ (calcium bicarbonate) + heat → $CaCO_3$ (calcium carbonate) + CO_2 (carbon dioxide) + H_2O (water)

In special cases and primarily with the use of well waters possessing a high natural iron content, deposition of iron oxide from the decomposition of ferrous bicarbonate takes place in accordance with the following reaction:

(2) $2\,Fe(HCO_3)_2$ (ferrous bicarbonate) + $\frac{1}{2}\,O_2$ (oxygen) → Fe_2O_3 (iron oxide) + $4\,CO_2$ (carbon dioxide) + $2\,H_2O$ (water)

In once-through systems, corrosion results primarily from the presence of dissolved oxygen, carbon-dioxide and low pH values. The corrosion reaction for dissolved oxygen may be illustrated as follows:

(3) $4\,Fe$ (iron) + $6\,H_2O$ (water) + $3\,O_2$ (oxygen) → $4\,Fe(OH)_3$ (ferric hydroxide)

The ferric hydroxide formed may later revert to iron oxide rust as follows:

(4) $2\,Fe(OH)_3$ (ferric hydroxide) → Fe_2O_3 (iron oxide) + $3\,H_2O$ (water)

It is pertinent to note that an iron-oxide deposit has resulted in reaction (2) as well as in reaction (4). The iron oxide formed in reaction (2) however, has not resulted from corrosion but from deposition of natural iron present in the water. In speaking of deposits which form in cooling water systems it is important that the mechanism causing the deposit be borne in mind, otherwise confusion may result. To distinguish between corrosion and scale formation the following definitions may be helpful.

In general, the term "scale" applies to deposits which result from crystallization or precipitation of salts from solution. Wasting away of a metal is the result of corrosion. While a deposit results in both cases, the mechanism of formation is different and the corrective methods necessary to prevent the deposit differ.

The factors affecting scale formation are temperature, rate of heat transfer, calcium, magnesium, silica, sulfate and alkalinity concentrations, and more pertinent—pH value. In a once-through system the magnesium, silica and sulfate concentrations are normally sufficiently low so that these factors do not enter the problem. The other factors, however, do apply in this type system.

By means of Langelier's equations, which take into consideration pH, calcium, total alkalinity, dissolved solids and temperature, it is possible to predict with a remarkable degree of accuracy whether a water is scale forming with respect to calcium carbonate. Briefly Langelier's equations permit calculation of the pH at which the water is saturated with respect to calcium carbonate at the temperature of use. If the actual pH value of the water minus the pH of saturation is a positive value, the water is over saturated with respect to calcium carbonate, and deposition of calcium carbonate will take place. If the actual pH value of the water minus the pH of saturation is a negative value, the water is under satu-

rated with respect to calcium carbonate, and no deposition of calcium carbonate will take place. In the absence of a deposit formation over the metal surfaces, corrosion from the dissolved gases present in the water will result.

Prevention of Scale and Corrosion in Once-Through Systems

Prevention of scale formation in once-through systems is primarily based on adjustment of the water balances in keeping with Langelier's equation, the application of materials possessing surface active properties or a combination of the two.

A surface-active material is one which possesses the property of preventing crystal growth and therefore scale formation. In effect surface-active materials broaden or increase the solubility of the scale-forming salts and permit an over-saturated condition of the salt to be present without precipitation. Materials of this type include special types of phosphates, tannins, lignins, starches and combinations of these materials. It is possible to select a particular blend of the various surface-active agents to secure the added benefits of each for the conditions in question.

Normally, the addition of a few parts per million of a surface-active agent fed proportionately to a water possessing a positive saturation index is sufficient to minimize scale formation in the form of calcium carbonate. However, where the degree of over-saturation is quite high so that excessive scale formation still takes place, even with the use of surface-active treatment, acid treatment or recarbonation to lower the alkalinity and/or pH is necessary. The adjustment of alkalinity and pH, in this case, need only be sufficient to reduce the degree of over-saturation within the effective range of the surface-active materials.

A special case of scale formation from ferrous bicarbonate precipitation was mentioned and illustrated by equation (2). Ferrous bicarbonate is considerably more unstable than calcium bicarbonate and is affected materially by the presence of oxygen and heat. The prevention of scale formation from ferrous bicarbonate can be accomplished by the addition of surface active materials and usually a dosage of 1 part per million of surface-active material per part of iron is required. When surface-active agents can not satisfactorily handle the problem, equipment must be installed for the removal of the iron.

In once-through systems, corrosion is primarily the result of dissolved oxygen and low pH values. Where a water possesses a negative saturation index, as calculated by Langelier's equation, no calcium carbonate deposit will form over the metal surfaces, and the dissolved gases will be free to attack the metal. The correction of this condition depends on rendering the water over-saturated with respect to calcium carbonate, to permit deposition of a thin protective film over the metal surfaces. The deposition must be evenly distributed over the entire metal surface so as to prevent the dissolved gases from attacking the metal. The materials commonly used for this purpose are soda ash, lime and caustic soda. They serve to neutralize the free acidity or carbon dioxide, and as a result increase the alkalinity and pH value. Lime not only increases the pH and alkalinity but the calcium content of the water as shown by the following reaction:

(5) $Ca(OH)_2$ (calcium hydroxide) + $2CO_2$ (carbon dioxide) → $Ca(HCO_3)_2$ (calcium bicarbonate)

Since the factors entering into the calculation of the pH of saturation include calcium as well as alkalinity and pH value, this material represents the most economical means of adjusting the saturation index to the positive side. Where large quantities of water are involved, the use of lime is most desirable from an economical standpoint. Lime must be fed in a slurry form and requires special and more expensive feeding equipment. Where the quantity of water involved is not large, the use of soda ash is preferred because of simplicity of feeding.

The adjustment of the water to an over-saturated condition will lay down a calcium carbonate deposit. To secure protection from corrosion the deposit must be uniformly distributed over the metal and at the same time excessive deposit build-up must be avoided; otherwise a material reduction in heat trans-

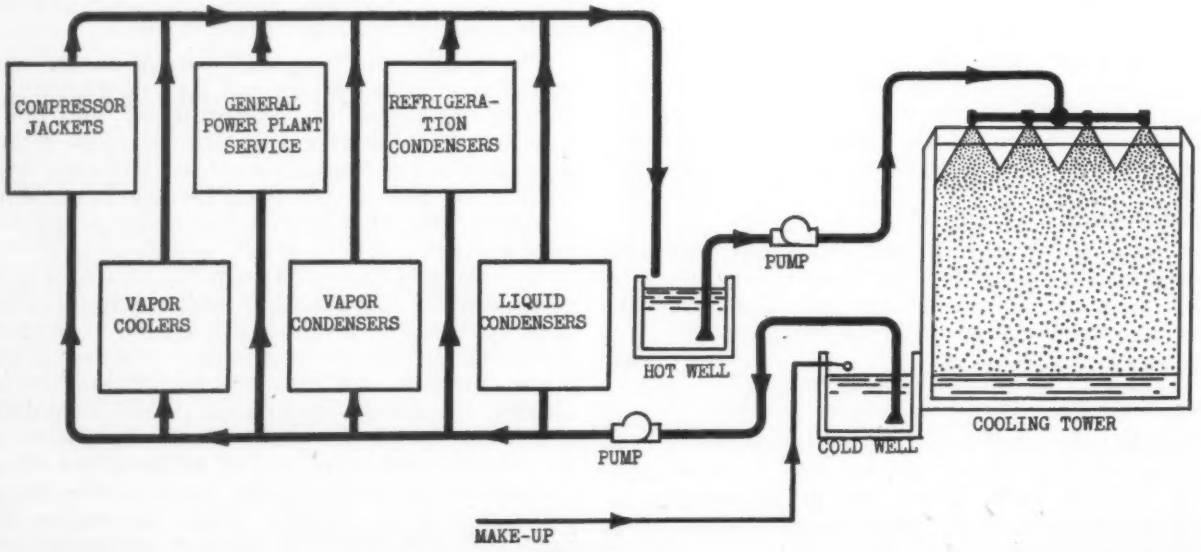


FIGURE 1

Typical water-cooling requirements of a petroleum refinery

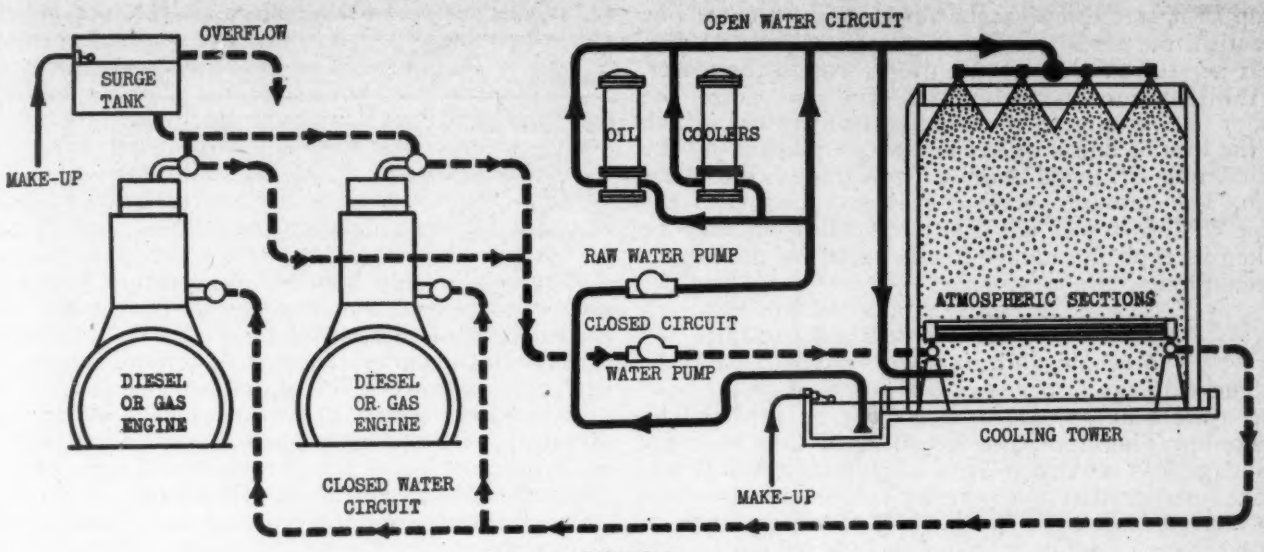


FIGURE 2

Typical flow diagram of a natural-draft cooling tower in diesel or gas-engine service

fer and carrying capacity of the system will result. This condition could readily result due to the temperature variation which takes place. For example, to assure the maintenance of a protective film on the metal surface at the point of lowest temperature, it is necessary to maintain an over-saturated condition at the lowest temperature. Therefore, while a small amount of deposit will result at the lower temperature, a large amount will result at the higher temperature. Where the difference between maximum and minimum temperature in the system is large, an undesirable amount of scale will deposit at the higher temperature. Since this corresponds to the point at which heat transfer is taking place, serious interference with rate of heat transfer will result. Therefore, in addition to rendering the water over-saturated, surface-active treatment must be employed to control the deposition.

While it is true that a positive saturation index indicates that a water is over-saturated with respect to calcium carbonate and therefore will give rise to deposits of calcium carbonate, this does not mean that corrosion will be absent. The interpretation of Langelier's saturation index must be tempered somewhat by the general characteristics of the water employed. It merely indicates the tendency of the water to form scale and not the quantity of scale that will form. For example, if a water possesses a low calcium content but a high alkalinity and pH value, calculation by Langelier's equation will show it to possess a positive saturation index and therefore calcium carbonate scale will result. However, by virtue of the low calcium content of the water the calcium carbonate that does deposit will not be sufficient to completely coat the entire metal surface and therefore attack from the dissolved gases will result.

Where the calcium content is low and a continuous film can not be expected to form, treatment of the water involves the use of materials which are capable of being absorbed on the metal surfaces and form a "film." Materials of this type include the special phosphates mentioned under surface-active agents and the silicates. Silicates are not surface-active agents, as the definition requires materials of this type to possess the property of preventing crystal growth or scale formation from a solution over-saturated with respect to the scale-forming salt. They are, however, capable of inhibiting corrosion by forming a protective film over the metal. The mechanism of film formation is believed to be the development of an insoluble adherent deposit with the metal involved. However, in the case of waters high in calcium or magnesium the deposit formed may be the calcium and magnesium silicates. Because it is possible to form excessive amounts of calcium and magnesium silicates which are difficult to remove by chemical or mechanical means, the application of silicates is best limited to waters of low hardness. Both the phosphate and silicate type treatments require an appreciable period for the protective film to form, as much as 90 days. While a small amount of benefit will result immediately, full benefit is not secured until completion of the film formation. To hasten the film formation initially, the use of higher concentrations may be employed, after which treatment may be decreased only to the amount necessary to maintain the film.

Open Circulating Systems

In the open circulating system, water flows through the heat-exchange equipment and absorbs heat and as a result has its temperature increased. It then flows to water-cooling equipment where the water in turn is cooled. The cooled water is then pumped back through the heat-exchange equipment and the cycle is repeated. Typical flow sheets of the open circulating system are illustrated by Figures 1 and 2.

Cooling of the water is brought about by use of spray ponds, atmospheric or natural-draft towers, and mechanical-draft towers.

The water in passing through the tower has its temperature decreased. To accomplish this cooling, the water must give up heat to the outgoing air. This heat is lost from the water as water vapor or evaporation. By virtue of the vaporation which takes place in cooling, the dissolved solids in the water become concentrated. The evaporation must be replaced by make-up water. The quantity of water lost by evaporation can be calculated from the conditions of the inlet and the outlet air. The evaporation loss will amount to approximately 0.85 to 1.25 percent of the

rate of circulation of water over the tower per 10° F. drop of water temperature through the tower. For practical purposes this figure may be taken as 1 percent per 10° F. temperature drop through the tower.

While the evaporation loss tends to cause the water to concentrate, the windage or drift loss, which is the loss of fine droplets of water entrained by the circulating air, tends to limit the degree of concentration. The amount of windage loss varies with the type cooling tower used, but the following may be taken as typical windage losses based on the rate of circulation.

Spray ponds = 1.0 to 5.0%
Atmospheric towers = 0.3 to 1.0%
Mechanical-draft towers = 0.1 to 0.3%

The windage also represents a loss of water from the system and this likewise must be replaced by make-up. Therefore, the evaporation loss plus the windage loss is equal to the make-up required. It was stated earlier that a 1 percent evaporation loss can be expected for each 10° F. drop of water temperature through the tower. This loss is based on the rate of circulation. The windage loss is also based on the rate of circulation. Accordingly, if the water were cooled 20° F., an evaporation loss of 2 percent would result. If the tower were the atmospheric type and were subjected to a windage loss of 1 percent, the total make-up would be 3 percent of the rate of circulation. Assuming a rate of circulation of 1000 gallons per minute this would require 30 gallons per minute make-up or approximately 43,000 gallons per day.

TABLE 1
Typical Analyses of Scales from Cooling-Water Systems

SOURCE—	Condenser (Percent)	Pipe Cooler (Percent)
Calcium oxide as CaO	49.79	39.85
Magnesium oxide as MgO	2.42	2.20
Iron and aluminum oxides as R_2O_3	0.82	7.50
Organic matter and oil	6.05	15.00
Carbon dioxide as CO_2	39.00	30.20
Sulfates as SO_3	1.29	0.50
Silica as SiO_2	0.15	3.85

The relationship between evaporation loss, windage and the cycles of concentration that the water will undergo is illustrated by Figure 3. To illustrate the use of the curves, assume a 20° temperature drop through the tower. This corresponds to an evaporation loss of 2 percent. From the typical windage losses illustrated for the spray pond, assume a windage loss of 2 percent. From the curves it will be noted that 2.0 cycles of concentration will develop. If the tower were of the atmospheric type and a 1 percent windage loss were assumed, with the same temperature drop through the tower, 3.0 cycles of concentration would result. In the case of a mechanical-draft tower with a windage loss of 0.3 percent and the same temperature drop, approximately 7.5 cycles of concentration would develop. It therefore can be seen that the type tower limits the maximum cycles that can develop in a cooling-water system.

In the circulation systems where the water is concentrated by evaporation, the problem of scale formation becomes more difficult. Not only is the tendency

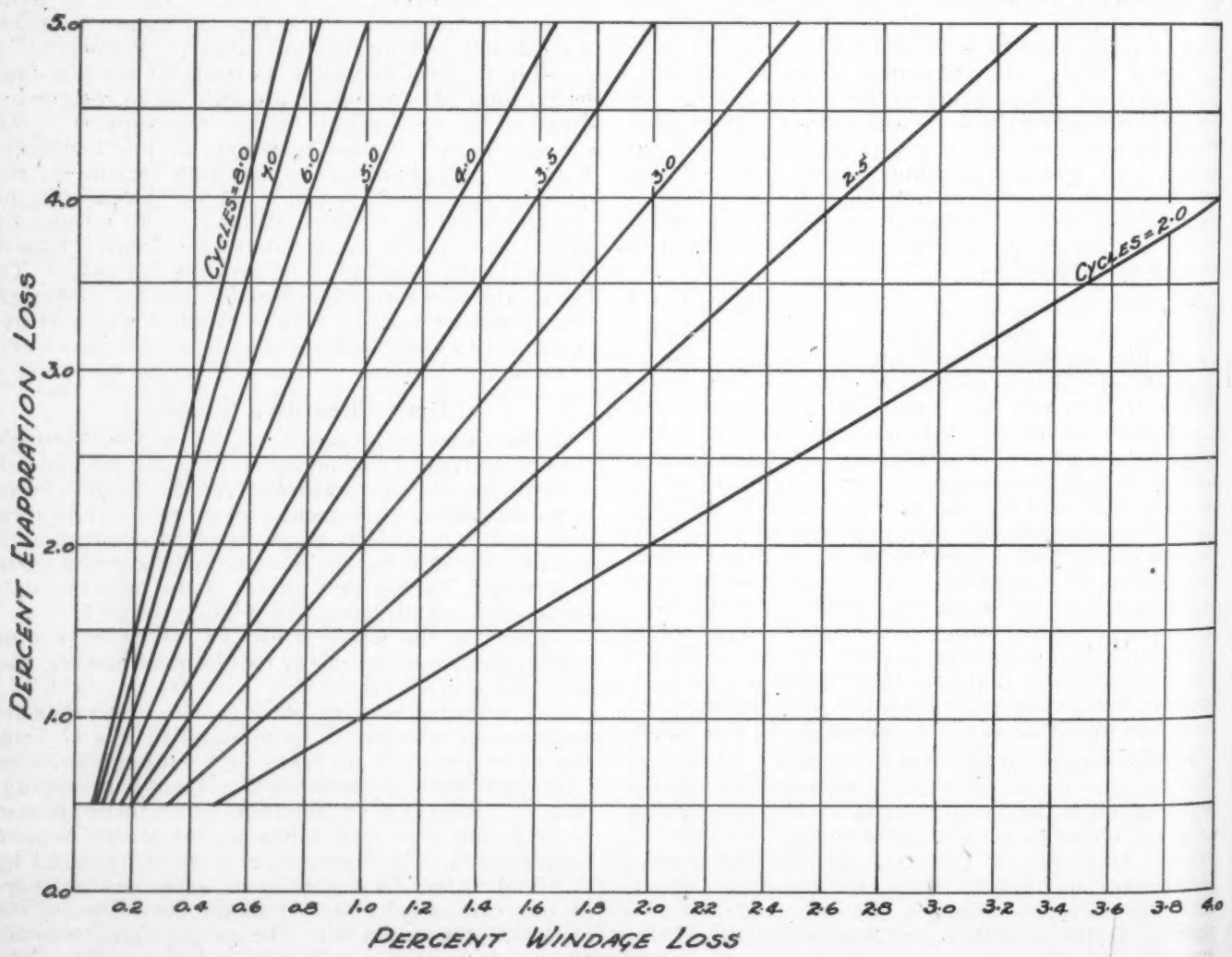


FIGURE 3

toward calcium carbonate scale formation greater, but the problem is intensified by the necessity to avoid exceeding the solubility of calcium and magnesium silicates and calcium sulfate.

While it is possible to predict with a remarkable degree of accuracy by means of Langelier's equation whether a water is scale forming with respect to calcium carbonate, in the case of calcium and magnesium silicate and calcium sulfate, prediction of scale formation in these forms can not be made with as great a degree of accuracy.

The curves in Figure 4 will serve to give some idea of the relative solubility of calcium carbonate compared to calcium sulfate. While the various forms of calcium sulfate are illustrated, the one normally encountered in cooling-water systems is gypsum. Due to the fact that calcium carbonate is considerably less soluble than calcium sulfate, the type scale formed in open circulating systems is principally calcium carbonate in the great majority of cases. Table 1 illustrates typical analyses of scale samples.

Prevention of Scale in Open Circulating Systems

The type treatments required to prevent scale formation in open circulating systems are similar to those employed in the once-through type system. However, quantities of treatment required are considerably higher, ranging in the neighborhood of 30 to 100 parts per million on the basis of the circulating water. The surface-active materials employed should be a definite blend best suited to the characteristics of the water encountered. The selection of the particular blend is based on maintaining the system as scale-free as possible by holding the hardness in solution, and in addition is based on assuring that what precipitate does form is in a fluid form possessing the least possibility of adhering to heat transfer surfaces.

It can readily be seen that in a system of this type where concentration takes place an excessive degree of over-saturation with respect to calcium carbonate can result, and in addition the solubility of calcium sulfate and calcium and magnesium silicate can be exceeded. To avoid an excessive degree of over-saturation of the scale-forming salts, it is therefore necessary to control cycles within a fixed definite range so that the degree of over-saturation is restricted within the effective range of the surface-active materials employed. Where the natural windage loss is insufficient to limit cycles of concentration, it is necessary to supplement the windage loss by means of blow-down. This blow-down normally takes the form of a continuous bleed of a small amount of water from the system. The quantity of blow-down required can be determined from the group of curves showing the relationship between evaporation, windage loss and cycles. For example, in the mechanical-draft tower it was illustrated that with a 0.3 percent windage loss 7.5 cycles of concentration would take place when the water underwent a 20° temperature drop. If the characteristics of the make-up water were such that a marked degree of over-saturation took place beyond the effective range of the surface active materials employed, additional blow-down would be required to restrict the over-saturation. Let it be assumed that 3 cycles of concentration would be permissible. Referring to the curves, Figure 3, at a 2 percent evaporation loss follow horizontally across to the intersection with the 3.0 cycle line, drop down and read windage loss as 1 percent. At 7.5 cycles the windage loss was 0.3 percent, so this represents an increase of 0.7 percent of the rate of circulation. With a circulation rate of 1000 gallons per minute, the supplementary blow-down required would be 7 gallons per minute. Make-up requirements would be increased to 3.0 percent compared with 2.3 percent of the rate of circulation.

In this particular illustration the rate of circulation was only 1000 gallons per minute and the supplementary blow-down rate 7 gallons per minute. The supplementary blow-down rate required is not very much. However, this rate of circulation is relatively small when it is considered that circulation rates in certain of the oil industries range anywhere from 10,000 to 125,000 gallons per minute. Both from the standpoint of water conservation and treatment requirements, it is not always permissible nor economical to increase blow-down. While the percentage of blow-down is small, it makes a large difference in quantity of make-up water. Where the degree of over-saturation develops beyond the effective range of surface-active materials and it is not economically feasible to increase blow-down to control the degree of over-saturation, it becomes necessary to employ supplementary treatment such as external softening of the lime-soda or zeolite types or the reduction of the alkalinity by means of acid treatment. The choice of which one of these methods to employ will depend on the characteristics of the water, the par-

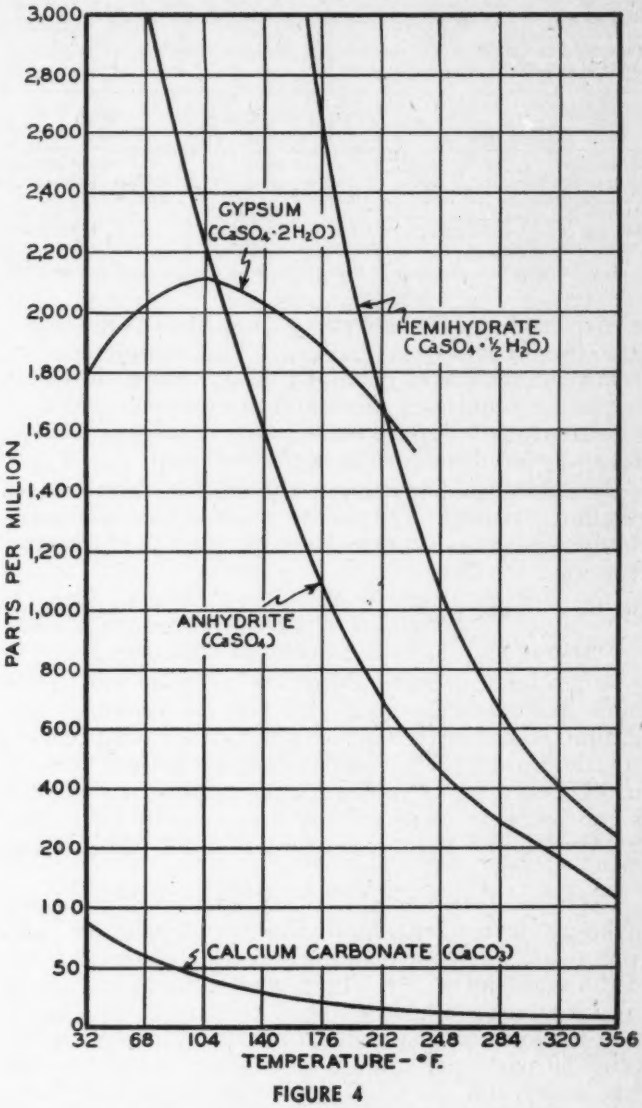


FIGURE 4

TABLE 2

	Raw Water	Circulating Water Without Treatment	Circulating Water With Treatment
Total hardness as $CaCO_3$	75	135	510
Sulfate as SO_4	20	60	1,265
Chloride as Cl	100	300	700
Iron as Fe	Trace	Trace	Trace
Alkalinity to phenolphthalein as $CaCO_3$	0	20	0
Alkalinity to methyl orange as $CaCO_3$	200	600	250
pH value	7.1	8.9	7.9
Silica as SiO_2	10	25	75
Calcium as $CaCO_3$	50	65	340
Magnesium as $CaCO_3$	25	65	170
Cycles of concentration	..	3	7

	Data Without Treatment	With Treatment
Circulation	6,000 g.p.m.	6,000 g.p.m.
Evaporation loss	2.5%= 150 g.p.m.	2.5%= 150 g.p.m.
Windage loss	0.3%= 18 g.p.m.	0.3%= 18 g.p.m.
Blowdown	57 g.p.m.	7 g.p.m.
Makeup	225 g.p.m.	175 g.p.m.
Cycles	3.0	7

ticular mechanical and cooling conditions at the plant, and the economics involved. The supplementary treatment with acid generally proves most desirable because it requires a minimum of equipment. Where acid treatment is deemed necessary, sulfuric acid is generally used because it is the cheapest.

By use of acid treatment the calcium bicarbonate alkalinity is converted to the more stable and more soluble calcium sulfate as illustrated by the following reaction:

(6) $Ca(HCO_3)_2 + H_2SO_4 \rightarrow CaSO_4 + 2\,CO_2 + 2\,H_2O$

calcium bicarbonate — sulfuric acid — calcium sulfate — carbon dioxide — water

It can be seen from Equation (6) that acid treatment decreases the alkalinity and by virtue of this minimizes the degree of over-saturation with respect to calcium carbonate. The calcium sulfate formed in this reaction, as shown by the curves in Figure 4, is considerably more soluble than calcium carbonate and therefore a greater concentration of this salt can safely be tolerated.

Table 2 illustrates the advantages in minimizing make-up water by employing supplementary acid treatment. The first column gives the characteristics of the make-up water. The second column illustrates the circulating water without treatment. It can be seen the system was under 3 cycles of concentration. With 50 parts per million of calcium present in the raw water and 3 cycles of concentration, the circulating water should contain 150 parts per million of calcium if none had precipitated in the form of sludge or scale. Only 65 parts per million was found which represents 43 percent of the expected amount. In the third column, the characteristics of the circulating water with acid treatment and a blended surface-active material is illustrated. It can be seen that by virtue of the acid treatment, the methyl orange alkalinity has been limited to 250 parts per million and the sulfate content of the water has sharply increased. The addition of the acid, however, has permitted the maintenance of 7 cycles of concentration compared with 3 cycles of concentration on the untreated water. At 7 cycles of concentration, with 50 parts per million of calcium in the make-up water, 350 parts per million of calcium would be expected in the circulating water. It can be seen that 340 parts per million of calcium was present which represents 97 percent maintained in the soluble form.

The data listed below the water analyses show that by virtue of a reduction in blow-down make-up requirements have decreased from 225 to 175 gallons per minute, a reduction of 22.2 percent.

In cases where the sulfate content of the make-up water is already high, supplementary sulfuric acid treatment will not be permissible, as the solubility of calcium sulfate would be exceeded and an increased rate of blow-down would be necessary. Where this is the case, external treatment must be employed. Since the water is to be used for cooling purposes, the methods of external treatment available are limited to those that are operated in the cold, such as lime-soda or zeolite types of softeners.

Prevention of Corrosion in Open Circulating Systems

The problem of corrosion in open circulating systems, like the problem of scale formation, is also intensified. The intimate contact of the air with the water renders the water completely saturated with respect to oxygen at the temperature encountered at the tower sump. In addition, where towers are located in industrial areas, the air may be contaminated with such gases as sulfur dioxide, ammonia and hydrogen sulfide. When corrosion is encountered, the water usually possesses a negative saturation index or it may even possess a positive saturation index, but the quantity of calcium present is insufficient to completely coat the metal surfaces and therefore attack from the dissolved gases will occur.

To secure a positive saturation index and permit the deposition of a thin protective-scale formation over the heating surfaces, cycles of concentration can be increased. Where this itself is insufficient, the addition of materials such as soda ash or lime may be utilized. Here again it is necessary to employ surface-active materials to control the deposition so as to avoid an excess of scale formation on the hotter heating surfaces to assure the development of a protective film of the most desired qualities.

This method of treatment to effectively prevent corrosion depends on the maintenance of a protective calcium carbonate film over the heating surface. Where the hardness content of the water is exceedingly low, it cannot be hoped that a protective film will form continuously over the entire heating surface.

Partial protection against corrosion may be secured in this case by maintaining the water balance at "equilibrium" with respect to the saturation index at the hottest temperature encountered in the system, and employing silicate types of treatment to form a protective film. However, this system of treatment is not widely applied to circulating systems of this type because of the inability to maintain rigid control of the water at equilibrium saturation index. Any increase of the index to the positive side would increase the tendency for scale formation of the calcium and magnesium silicate types on the hot heating surfaces, and would result in serious interference with heat transfer.

It would be well to point out that less risk is involved in preventing corrosion by means of a calcium carbonate type film. In the first place the calcium carbonate deposition interferes less with heat transfer. In addition, it is not too difficult to remove by chemical or mechanical means. Most important, however, is the fact that should an excessive build-up of calcium carbonate take place it would be possible to operate the system with a negative saturation index for a period of time to permit gradual disintegration of the calcium carbonate deposits. The gradual disintegration can take place without shutting the

system down. This cannot be done where silicates are used to maintain the protective film.

When the system of maintaining a protective deposit formation cannot be satisfactorily applied, protection against corrosion can be brought about by use of chemicals which possess the property of rendering the metal surfaces passive. Chemical passivity may be defined as the property of permitting the formation of a microscopic film over the metal surface, which serves to depress the solution potential of the metal and in effect renders the metal more noble. This property of chemical passivity is possessed to a varying degree by such materials as phosphates, chromates, nitrites and various nitrogenous organic materials.

Of particular importance is the fact that the protective film of microscopic thickness is formed in a very short time, generally a matter of hours. In addition, the film can be formed at pH ranges of 6.0 and above.

The use of these materials is limited, however, based primarily on economics. The concentration of treatment required is quite high, varying anywhere from 500 to 1000 parts per million or more, making the system expensive. In addition they cannot be used with certain type waters as they are affected to some extent by reducing agents. The control is critical from the standpoint that low concentrations of materials of this type may possibly cause accelerated corrosion.

Closed Circulating Systems

Figure 2 also illustrates this type system. This is one in which the water is circulated through the heat-exchange equipment where it absorbs the heat, has its temperature elevated, and then circulates back through another heat exchanger over which cold water flows to again lower the temperature of the water, and the cycle is repeated. In a system of this type no evaporation takes place and therefore the water does not concentrate. At the same time, the water is not subjected to aeration. In addition, make-up requirements to a system of this type are quite small and are primarily limited to the amount of leakage. Even the very large systems require a make-up of only approximately 100 to 200 gallons per day.

Due to the lack of concentration, the problem of scale formation in this type system is not great, except in the case where extremely hard waters are used for make-up. Generally, corrosion is the main problem. Because of the small amount of make-up normally required, the use of softened water or condensate is economically permissible. In any event the treatment to prevent scale formation makes use of the surface-active agents and this in itself is normally sufficient. For the prevention of corrosion, materials possessing the property of rendering the metal surfaces passive are best suited and can be economically employed because of the small amount of make-up involved.

Biological Fouling

In industrial cooling-water systems, biological fouling in the form of slime and algae growth is a problem as serious as scale formation and corrosion, and in some cases is more serious. Slime and algae growth can cause corrosion and in addition act as a binder for scale-forming salts and result in serious interference with heat transfer.

Algae growths are composed of millions of tiny plant cells which multiply rapidly and produce large masses of plant material in a very short time. These are most familiar to us in the form of the green scum that makes its appearance predominantly in the spring and summer.

Slime growths are composed of a dense gelatinous mass of micro-organisms, principally bacteria and protozoa, with some algae and fungi. The distinction between algae growths and slime growths is primarily that the algae growths are composed of plant life while slime growths are rich in simple animal life.

Of the systems discussed, the closed circulating system is the only one not seriously affected by these growths. Each of the other systems are, however, very materially affected.

The chemicals most generally used to eliminate and prevent slime and algae troubles are those which exert a toxic action upon the causative micro-organisms. Included in this group are chlorine, chloramines, copper sulfate, mercury and other heavy metal compounds, potassium permanganate and chlorinated phenols, such as sodium pentachlorphenate.

The choice of the proper chemical or combination of chemicals to employ for any particular water is dependent upon a number of physical and chemical factors which include temperature, rate of circulation, retention time, aeration, and chemical composition of the slime and algae deposits, and of the water to be treated, inasmuch as the presence of constituents which might interfere or react with the toxic chemical may be present. The three most commonly used algaecides are chlorine, copper sulfate and the chlorinated phenols.

Chlorine in its various forms has been widely used. Its toxicity is remarkably high and it acts quickly. It is fairly general in toxicity for most bacteria, algae and protozoa and the maintenance of as little as 0.5 parts per million residual will kill most species. In a once-through system, a continuous application of chlorine is generally economically impossible. In such cases intermittent treatment has been used successfully. The use of a relatively heavy dosage over short periods serves to kill and remove any growths which may be formed during the intervals that no treatment is used.

The use of chlorine in recirculating systems is not widely practiced as it is difficult to maintain a residual chlorine content because of loss due to aeration and volatilization. Inasmuch as the most effective types of surface-active agents include the use of organic materials, the oxidizing effect of chlorine on these materials may be a disadvantage.

Copper sulfate has a rather high degree of toxicity to the simplest type algae but is generally less toxic to protozoa and bacteria, the slime formers. Inasmuch as the toxic effect of copper sulfate is due to the copper ion, it cannot be advantageously used for slime control in alkaline waters, as the free hydroxyl ion precipitates the copper ion as insoluble copper hydroxide. In addition, precipitation of the copper may accelerate corrosion.

Sodium pentachlorphenate is a relatively new organic chemical. It has been found particularly toxic to algae and slime-forming organisms in industrial cooling-water systems. In addition to its high degree of toxicity to algae, fungi, bacteria and protozoa, it is highly stable in alkaline waters, is not lost on aeration and is compatible with the organic type surface-active materials used in preventing scale.

The control of slime and algae growths is not a

simple matter and to a large extent must be based on observations and a trial-and-error procedure. In general the top of the cooling tower makes a desirable observation point, for it is here that water is warm and exposed to the sunlight. These conditions are favorable for growth and generally the slime and algae will first make their appearance at this point. In general it is best to employ the intermittent method of feed of large quantities of an algaecide rather than the continuous method of feeding small quantities. The micro-organisms responsible for slime and algae growths, if continuously subjected to small dosages of an algaecide, may after a period acclimate themselves to its presence and build up an immunity so that increasingly greater amounts of the algaecide will be required to kill them. Another disadvantage of the use of small amounts of an algaecide is that the dosage may only be sufficient to kill the least resistant types of organisms and while initially the growth may consist of a small percentage of the more resistant types, after a period of time it will be composed almost totally of the more resistant types, thereby intensifying the problem of slime and algae control.

It is also pertinent to point out that algaecides do not dissolve slime and algae growths. When systems are permitted to become heavily fouled with slime growths, the use of an algaecide can only serve to remove the organisms to the extent that it will lose its clinging action and be swept free by the circulation. Plugging at points of slow circulation may result under these conditions. Accordingly, it is imperative that the growths be controlled from the outset, and when a system is heavily fouled it is best to clean it mechanically before starting treatment. In certain cases the application of heavy dosages of chlorine will greatly assist in removing the growth.

Oftentimes, because the micro-organisms become acclimated to the presence of the algaecide, or possibly due to a change in the type of micro-organisms, growths will develop in a system that has been successfully treated with a particular algaecide. When a condition of this type develops a dual system of treatment will prove more effective employing two algaecides, alternately slug feeding to the system on separate days first with one and then the other. The frequency and dosage should be varied as required, based on observation of the results.

Summary

Water-treatment engineers have made considerable advancement in the development of corrective methods and chemicals to overcome the problems encountered in cooling-water systems. With present knowledge, experience and materials available, almost any cooling-water problem can be adequately controlled so that the expense of cleaning, maintenance and replacement of heat exchange equipment can be reduced to a minimum if not eliminated. The necessity for competent water treatmnt and close control of water balances is rightfully receiving an increased amount of recognition.

Baytown Ordnance plant built and operated by Humble Oil & Refining Company. This plant produces toluene, and supplied two thirds of the output of this material during the first year after Pearl Harbor. Part of the water-cooling equipment is shown in the foreground.

THE RELATION OF

Aviation-Fuel Quality

TO ENGINE PERFORMANCE

DR. W. J. SWEENEY
Standard Oil Development Company

THE chief limiting factor in aviation-fuel performance today is the familiar tendency of most petroleum hydrocarbons to knock under increased power conditions, thus to threaten destruction of the very engines they operate.

I will try to demonstrate, as simply as possible, how this one ceiling factor limits both the performance and the range of operation in an aircraft. In the course of this discussion of the phenomenon of knocking, I will point out why there is need for considerably more full-scale engine-test data to guide our further improvement of fuel quality. The improvement may come through better knowledge of the anti-knock qualities of various individual hydrocarbons. This in itself is a complicated problem because there are possibly millions of hydrocarbons present in petroleum. Alternately the improvement may come through better engine design to meet knock conditions. In many case, the measure of this improvement must be made by closer reference to actual test data, obtained in representative aircraft engines and with the accuracy now afforded to us by the new unit you are to see in operation later today.*

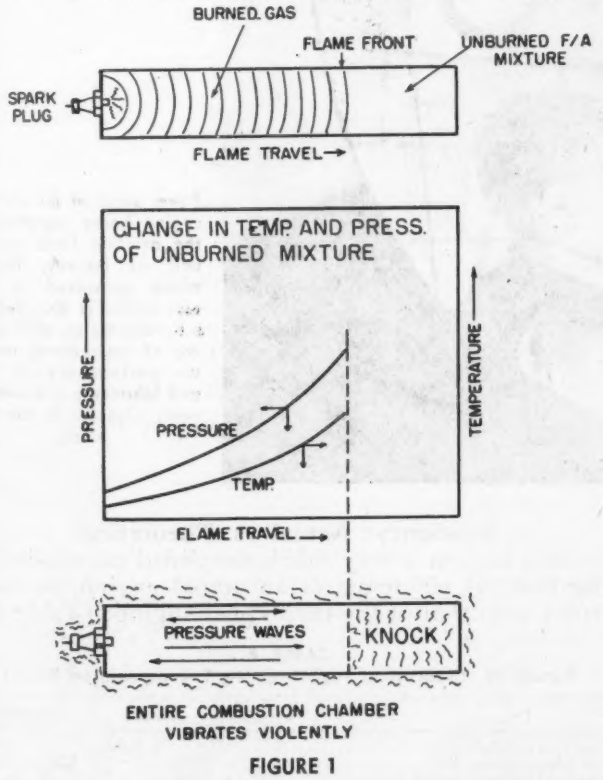


FIGURE 1

To perform its function, the aircraft engine must produce the maximum amount of power, consume the lowest possible amount of fuel, and weigh as little as is consistent with the strength it must have to withstand the terrific stresses imposed upon it Unfortunately, these things are to a considerable degree contradictory: for example, the power output of the engine when operating at its best economy (on the lowest weight of fuel) may be limited by knocking. To obtain maximum power, it is necessary to take steps to avoid this knocking. This is done by enriching the mixture — feeding to the engine a larger proportion of fuel to air than it theoretically needs to produce that power.

Knock—A Bad Actor

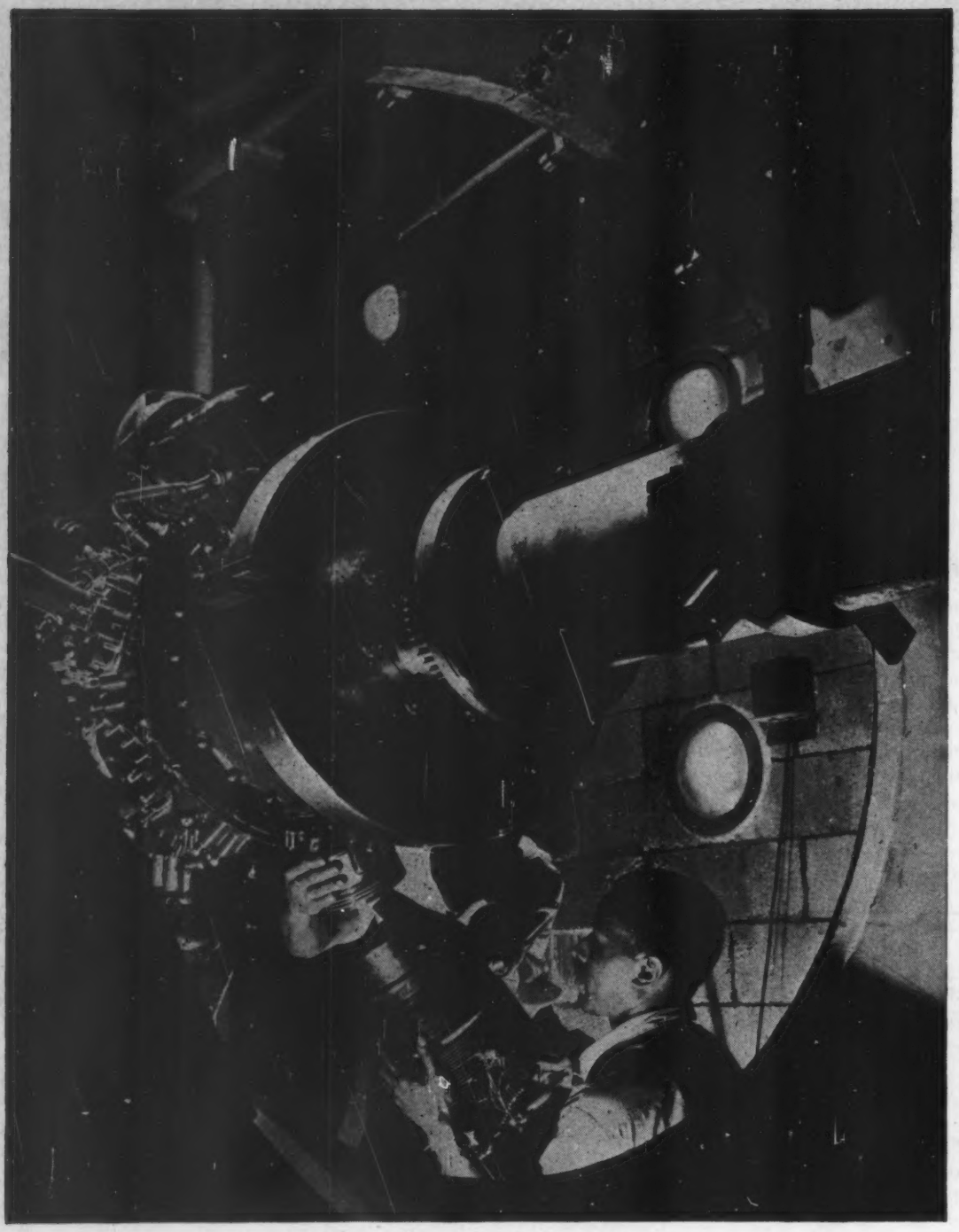
Before looking into the reasons why this is so, let us first see what knocking is: In Figure 1 is shown a tube of fuel-air mixture, ignited at one end by a spark plug. The following sequence of events occur:

1. Ignition of the mixture by the spark plug.
2. Relatively slow burning of the mixture, progressing away from the spark plug.
3. Rapid increase in pressure and temperature of the unburned portion of the mixture ahead of the flame front until a condition is reached which makes that unburned mixture explode violently or detonate.
4. Pressure waves set up within cylinder, resulting in knock; rapid scrubbing of walls by vibrating gas, rise in temperature of walls, loss in engine power, and eventual destruction of parts.

If fuels did not vary in anti-knock quality or tendency to knock, they could all be evaluated reasonably by one characteristic—the number of heat units (Btu) per pound. However, knock is a very bad actor. It limits economy (range of operation) and it limits power (performance).

Modern aircraft fuels are miracles of high anti-knock quality. They have permitted engines to be built capable of developing power outpus undreamed of only a short time ago. This great team of engine and fuel powers our fighting aircraft today. Nevertheless, these engines must still employ rich, relatively uneconomical mixtures to develop maximum

*This paper was delivered as part of the program of dedication of the aviation engine test stand by Standard Oil Development Company, Bayway, New Jersey, September 19 (see page 136).



Power shaft of an aircraft engine being installed in the aviation fuels testing unit at Bayway. Horsepower generated by the test engine is absorbed by a dynamometer, while dozens of instruments measure performance of fuel and lubricants in a control room adjacent to the test block.

power for take-off, climb, and high speed in order to function on lean, economical, mixtures during normal cruising operation. The reasons for this will be seen as we go along.

An aircraft engine is a device for converting heat energy into mechanical energy or useful work. Its working fluid is air—or, more accurately, nitrogen from air plus the products of combustion. These combustion products are the gases carbon dioxide, carbon monoxide, water vapor and hydrogen, in varying proportions depending on the conditions of burning in the cylinders. It is a fact not generally appreciated, that the power output of a gasoline engine is more nearly proportional to the amount of air (or oxygen in the air) burned than to the amount of gasoline consumed. This should be kept in mind. It is the reason why aircraft engines are supercharged or "boosted" to increase manifold pressure for take-off and for operation at high altitudes.

Efficiency: Actual vs. Theoretical

Let's look at a very much simplified calculation of the thermal efficiency of an actual engine, as compared with that of the theoretical engine: (Table A).

TABLE A
Actual vs. Theoretical Engine (7 to 1 Compression Ratio)

	Actual		Theoretical	
Total heat in fuel, Btu/lb		19,000		19,000
Heat lost to exhaust, Btu	6,500		8,500	
Heat lost in cylinder cooling, Btu	6,000		0	
Total heat lost, Btu		12,500		8,500
Usable heat: available to produce work		6,500		10,500
Thermal Efficiency ($\frac{\text{Usable heat}}{\text{Total heat}}$)	34%		55%	
Theoretical pounds of fuel per brake horsepower hour (no heat losses)	(0.134)		(0.134)	
Actual pounds of fuel per brake horsepower hour at stated efficiency	0.394		0.244	

The actual engine is naturally much less efficient than the theoretical engine, since it has mechanically

operated valves which require time to open and close, thus permitting dilution of the fuel charge with exhaust gases, and because the mixture will not burn instantaneously after ignition. Moreover, it is impossible in an actual engine to prevent heat loss from the gas to the walls, and the temperatures that the metal parts of the engine can stand are limited, so heat must be removed in order to keep temperatures of cylinders and pistons within safe limits. Heat likewise is removed by the lubricating oil. All this means fins for cooling cylinders and lubricating oil, which place an added drag on the airplane; special metals to withstand high temperatures, engine lubricants to function under these severe conditions, and many other problems which the designer, the metallurgist and the oil refiner must solve.

Roughly speaking, the total heat in a pound of fuel is divided as shown in Table A. This, however, applies only to operation with the theoretically correct ratio of fuel to air—typified in practice by cruising conditions at low power output. For high power output, as at take-off, an engine designed to give maximum fuel economy at cruising conditions must run with a rich mixture—a higher ratio of fuel to air—for otherwise it would knock, overheat, and quickly be destroyed.

Rich Mixture Reduces Knock

The simple chemical equations in Table B show why rich mixtures produce less heat, hence less knock. They show the relative volumes of gases produced and the relative quantities of heat evolved when a given volume of oxygen in the air combines with or burns a hydrocarbon in lean mixture and in rich mixture respectively.

TABLE B

100 Percent of Theoretical Fuel

(Cruise or maximum economy lean mixture—fuel/air ratio = 0.067)

$$1\ CH_2 + 1.5\ O_2 \rightarrow CO_2 + H_2O$$

Heat evolved = 19,000 Btu/lb. fuel
or 1,270 Btu/lb. air

150 Percent of Theoretical Fuel

(Take-off or full power rich mixture—fuel air ratio = 0.10)

$$1.5\ CH_2 + 1.5\ O_2 \rightarrow 0.53\ CO_2 + 0.97\ H_2O + 0.97\ CO + 0.53\ H_2$$

Heat evolved = 10,900 Btu/lb. fuel
or 1,090 Btu/lb. air

The equations in Table B show that, with rich mixtures, the heat evolved per pound of fuel or per pound of air is reduced. This produces less temperature rise in the cylinders, and less tendency to knock. This permits an increase in air supplied to the engine by means of added boost or supercharging, and added fuel, and this in turn permits greater power outputs before knocking again occurs.

Although all fuels will knock less in rich mixtures than at the theoretically correct fuel-air ratio, some are better than others in this respect.

Effect of Mixture Change on Power and Economy

Tables C shows what this means in terms of power output and fuel consumption in an aircraft engine of 2000 rated brake horsepower.

Here we see that fuel consumption at cruise, the condition of best economy, is 0.40 pounds of fuel per brake-horsepower-hour. For the increase of 600 horsepower to bring the engine to rated continuous power, fuel consumption is at the rate of 0.82 pounds per brake-horsepower-hour, and thermal efficiency is reduced to 16 percent. Fuel consumption for the increase from rated 2000 to 2400 take-off horsepower jumps to 1.38 pounds per brake-horsepower-hour, and thermal efficiency for the same range drops to 10 percent. Full power, rich-mixture operation is expensive.

Effect of Fuel Quality on Economy and Performance

This indicates where improvements in fuel quality can, in the future, help reduce airplane operating costs or improve performance. There are a number of ways that these benefits might be effected:

1. Same cruise quality but better rich mixture quality, so that same power as at present can be obtained with less enrichment. Result: better economy.
2. Same cruise quality but better rich mixture quality, so that greater power can be obtained with same enrichment as at present. Result: better performance. (Such performance helped win the Battle of Britain.)
3. Better cruise quality and same rich mixture quality. Result: greater range of operation. (This fuel may help win the Battle of the Pacific.)
4. Better cruise quality and better rich mixture quality. Result: greater range and better performance. (Such a fuel would be an improvement over (3) and would be even more valuable in the Japanese conflict.)

Knock and Economy

Figure 2 shows how knock effects economy or range of operation of an aircraft. The higher the compression ratio—and accordingly the higher the temperature—the better will be the resulting economy for a given power output. Neglecting mechanical considerations, the tendency of a fuel to knock limits the compression ratio wih which it can be used, and hence the economy or range that can be attained.

Knock and Power

Figure 3 presents three schematic indicator cards showing the increased cylinder pressures, and hence greater powers, which are obtainable without knocking when richer mixtures are used. (For simplicity the power increase that is gained in practice by increasing speed has been neglected.) Three work areas are shown: the shaded aera is work (power developed) at cruise conditions; the area surrounded by the dotted line is work at rated continuous power conditions; and the unshaded area surrounded by the solid line is work at take-off conditions. These roughly represent he three conditions listed in Table C. In each case the limit of permissible power is due to knock, but different fuels will show different rates of change in permissible power with rate of change in fuel-air ratio.

Automatic Carburetor Adjustmens to Meet Operating Conditions

The necessary adjustments to handle these changes in fuel-air ratio are complicated, and to relieve the pilot he carburetor is designed to take care of them, automatically, as shown in Figure 4. There are two settings—"automatic lean" and "automatic rich," determined by experience, and the pilot has the choice

TABLE C

	Cruise	Rated Continuous	Take-off
Horsepower delivered	1,400	2,000	2,400
Lbs. fuel consumed per hour	560	1,050	1,600
Gallons fuel consumed per hour (assuming 6 lbs. per gallon)	94	175	266
Fuel/Air Ratio	0.07	0.085	0.10
Total heat in fuel, Btu (assuming 19,000 Btu per lb.)	10,600,000	20,000,000	30,400,000
Heat to produce power, Btu	3,600,000	5,100,000	6,100,000
Heat lost, Btu (difference)	7,000,000	14,900,000	24,300,000
Fuel consumption rate, overall lb. per bhp-hr.	0.40	0.525	0.67
Thermal efficiency, overall	34%	26%	20%

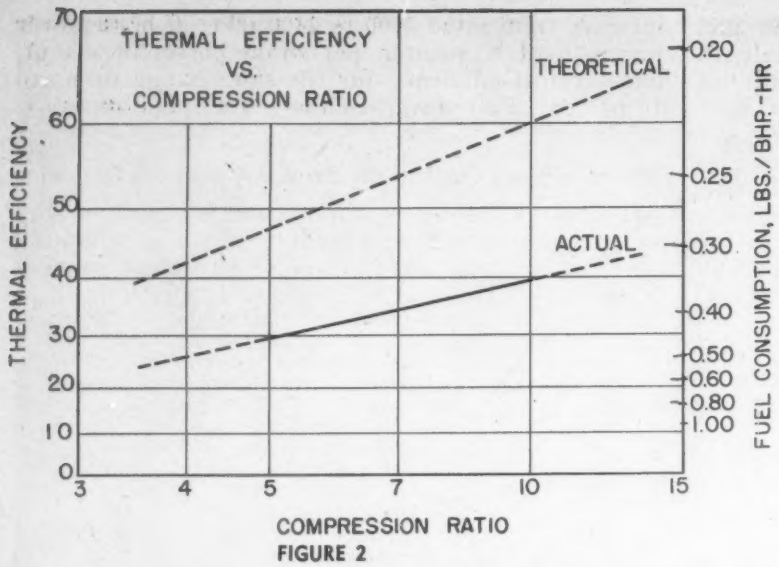


FIGURE 2

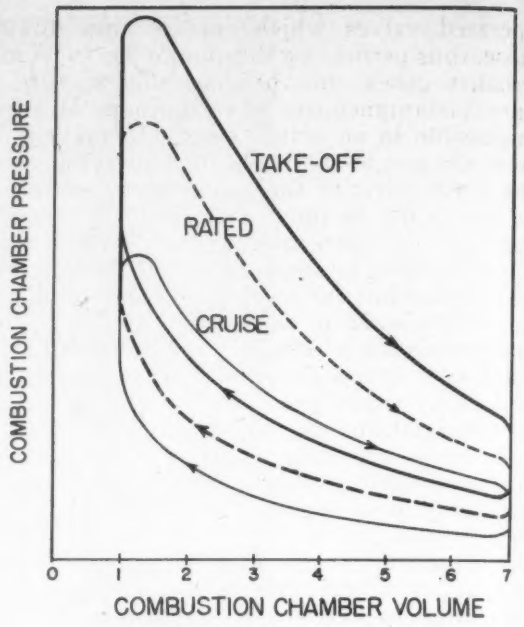


FIGURE 3
Pressure-volume relationship

of either to obtain economy or power as required. With these settings the carburetor automatically supplies enough fuel based on the quantity of air passing through its throat to prevent knock under any normal condition when running on the proper fuel. In certain large long-range aircraft, however, the flight engineer may override the controls manually and approach incipient knock as closely as he dares in order to obtain maximum economy and hence greatest range.

Fuel Quality Variations Under Different Operating Conditions

A comparison of fuel quality on a lean-mixture performance and a rich-mixture performance basis is admittedly an over-simplification of the knock problem because other variables enter into the picture—such as compression ratio, spark advance, cylinder cooling, mixture temperature, speed, hot spots, etc. Nevertheless, the wide differences in fuel quality under different operating conditions can readily be shown by such a comparison.

There are millions of hydrocarbons possible and the number present in petroleum is probably in the hundreds of thousands. In the gasoline boiling range alone the number possible is around 5000. Of these, however, only a few dozen known to be of superior anti-knock quality. Table D below gives a comparison of relative knock quality of some of these hydrocarbons with prewar commercial fuels (the completely arbitrary scale used is not to be confused with octane number).

TABLE D
Comparison in Anti-Knock Quality of Pure Hydrocarbons and Prewar Commercial Fuels
(All with same lead content except where indicated)

Hydrocarbon	Lean Mixture	Rich Mixture	Difference
A	77	100	+23
B	70	93	+23
C	57	99	+42
D	54	76	+22
E	47	49	+ 2
"100 Octane" (1938)	42	52	+10
F	42	46	+ 4
G	42	40	− 2
H	31	34	+ 3
"91 Octane" (1938)	28	37	+ 9
I	21	19	− 2
J	21	15	− 6
K	14	14	0
"73 Octane" (1938) (no lead)	2	9	+ 7

These ratings are not true quality measurements, but do serve to indicate the wide variations in fuel performance that can be obtained by varying engine operating conditions. The great differences in the lean mixture and rich mixture ratings of some of these fuels show that it is extremely important that the tests used to evaluate the fuels determine their quality in actual flight.

Figure 5 shows graphically the data in Table D. Two things are of particular interest:

1. Existence of hydrocarbons that, with both lean and rich mixtures, exceed old style 100-octane gasoline in anti-knock quality.
2. The extremely great rate of change in anti-knock quality, in many cases, between lean mixture and rich mixture. Should the latter more nearly represent average flight performance than the former, the actual relative performance would in some cases be the opposite from that derived from data based on lean mixture ratings.

Figure 6 shows a similar quality relation between old commercial fuels and a few presently available

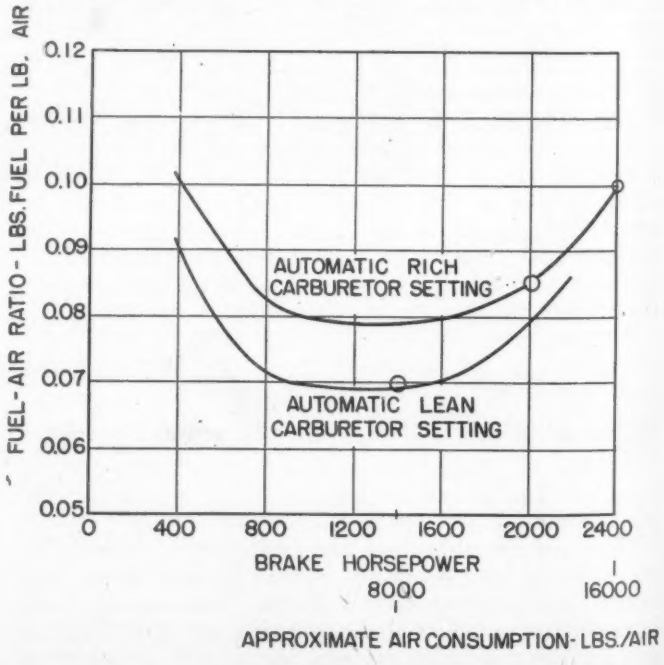


FIGURE 4
Typical mixture curves

commercial blending agents. The same two points are seen.

Assuming that between the two extremes lie actual knocking conditions experienced in flight, it is obviously important to know just where incipient knock is reached under different flight conditions and in different engines.

Evaluating Fuel Quality

To redesign engines and aircraft to take full advantage of fuel improvements is no easy task. One phase of the job is to prove by adequate full-scale engine tests that the fuel has the added quality, how much and under what conditions of operation. Another is to determine what changes in superchargers, carburetors, ignition systems, coolers, etc., must be made to get the most from the new fuel-new engine combination. The fuel and the engine are, in a sense, like the hen and the egg—which comes first?

The engine manufacturer cannot build his engine in production quantities until the fuel it needs is commercially available. The refiner cannot build the equipment for making the fuel without knowing what its composition must be to meet the needs of the engine. The fuel designer in his laboratories must arrive at this composition on the basis of practical tests. To meet this need—the very foundation of fuel and engine improvement—Standard Oil Development Company has built a full-scale multicylinder engine-test stand.

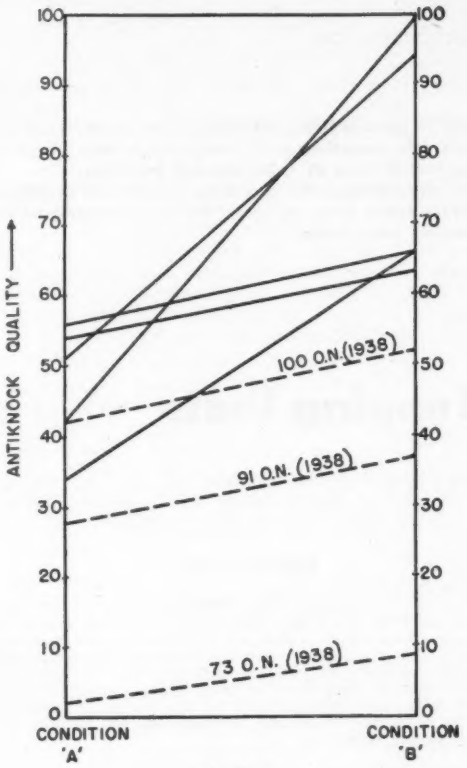


FIGURE 6
Commercial blending agents

Importance of New Multicylinder Test Stand

It is quite impossible to do all fuel-test work on engines in flight, for several good reasons. For example, flight conditions of air-temperature-to-carburetor and air-temperature-to-cooling-fins cannot be reproduced from day to day. Also, it is desirable in rating fuels to approach knocking conditions—thereby occasionally developing true knock, a most dangerous condition in flight. While a good bit of flight data are absolutely necessary, it is generally desirable to obtain the background data on full-scale laboratory engines and then to check special points by flight tests. It is for such evaluations of presently available commercial blending agents and of promising experimental products that the new full-scale test stand has been built.

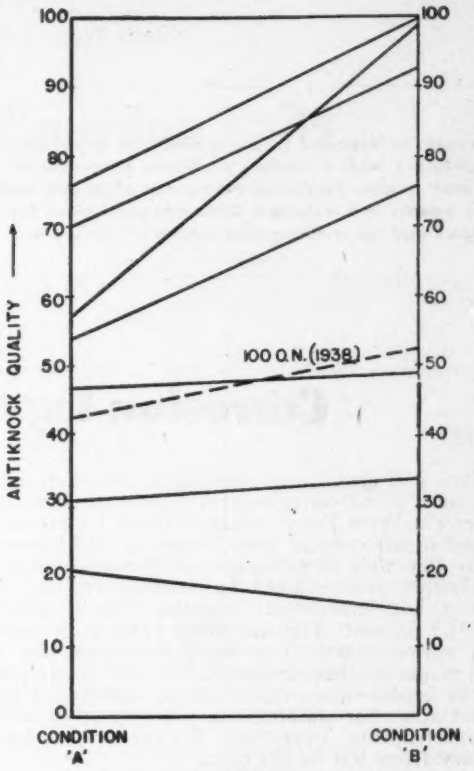
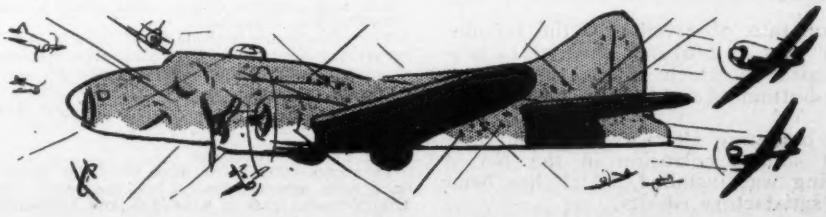


FIGURE 5
Pure compounds

By present standards, petroleum as found in nature provides very poor aviation fuels. Broken down and synthesized, however, it gives exceedingly good fuels. As it will be produced in the future, petroleum gives promise of even greater improvements in antiknock quality. Even now—in the midst of war—much can be done to improve fuel quality by selection of available products and modification of existing plants. Such improvements are the immediate aim of all of us operating the test stand, so that no matter how long the war, the Armed Forces will have available the best possible fuels compatible with the huge amounts required.



PROCESSING OF
West Texas Sour Crudes

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THIS report is intended to summarize the experience gained in this refinery with corrosion problems encountered in processing sour crudes. Corrosion rates, use of alloys, and use of alkaline agents are included. Data are presented for topping in Section I and for cracking and coking in Section II.

Section III is included to summarize our experience in desalting crude oils, together with data which may be of value in justifying installation of salt-removal facilities.

Section IV summarizes the standard safety and maintenance practices which have been adopted for the handling of equipment processing sour crude.

SECTION I

Corrosion Experience—Topping Units

THE data included here have been obtained from the operation of a 35,000-barrels-per-day topping unit, processing 100 percent West Texas crude of about 1.5 percent sulfur content and a salt content after desalting of 11 pounds per M barrels. The unit is comprised of three columns which successively take overhead hexanes and lighter, light straight-run gasoline, and straight-run naphtha. The on-stream time averages 94.5 percent. The operating cycle is 6 months per run, with approximately one week downtime for maintenance and inspection between runs. The unit is equipped with seven direct-fired heaters, which are so manifolded that they can be shut down for maintenance and inspection as required without interrupting operation. Heater-tube inspection periods vary from 100 to 180 days.

The light straight-run gasoline and straight-run naphtha are scrubbed with caustic soda at the unit to remove H_2S, while NH_3 is injected into the vapor lines from the three fractionating columns (in sufficient quantity to maintain the pH of the accumulator water at 8.4) to reduce corrosion to the condenser shells and tubes. Chemical consumption is as follows:

Caustic Soda	0.2 lb./bbl.
Ammonia	0.04 lb./bbl.

Corrosion rates for individual equipment items are as follows:

Columns

No. 1 Column
The column operates at a top temperature of 200° F. and a bottom temperature of 450° F., taking hexanes and lighter overhead. The vessel is all steel with steel trays and cast-iron caps. Corrosion allowance is 3/16-inch. No significant corrosion has been observed in over two years of operation.

No. 2 Column
Operating temperatures are 320° F. top and 550° F. bottom, taking light straight-run gasoline (180°-290° F.) overhead. The column is steel (¼-inch corrosion allowance) with steel trays and cast-iron caps. No significant corrosion has been observed in four years' operation.

No. 3 Column
Operating temperatures are 345° F. top and 650° F. bottom, producing 440-end-point straight-run naphtha overhead and a 680-end-point gasoil sidecut. Originally, this column was steel (¼-inch corrosion allowance) with stainless type 405 alloy trays and caps below the feed tray, and steel trays with pressed steel caps above the feed tray. Corrosion was encountered below the feed tray.

The maximum corrosion rate, observed near the reboiler return, was 6/64-inch per year. A 5/64-inch liner of 12 percent chrome steel was installed which covers the bottom head and shell up to the bottom of the tray above the feed tray.

A similar topping unit operating alternately on sour and sweet crude experienced similar corrosion in the No. 3 Column, and a brick lining was installed, which has been in service five years with satisfactory results.

Some localized corrosion, observed on the top tray adjacent to the reflux return sump, has been eliminated by installing a monel liner over the area attacked.

Heater Tubes

No. 1 Column Reboiler
This heater is a standard Foster-Wheeler heater, end fired, with radiant tubes on both sidewalls. The coil outlet temperature is 500° F. The tubes are steel, 5-inch I.P.S. with .375-inch wall and 6-inch with .432-inch wall. The maximum corrosion observed occurs in the radiant bank where an average rate of 36/64-inch per year is experienced. However, the corrosion is irregular. In some cases, ruptures have occurred on one side while the opposite side of the tube is relatively free of attack. In all cases the maximum corrosion occurs on the side of the tube exposed to the flame.

No. 2 Column Reboiler
The heaters in this service are of the strictly convection type with the tubes arranged in 11-12 horizontal rows above the firebox. The maximum corrosion rate occurs in the bottom (radiant) row, the average rate being 70/64-inch per year in this row. Life is about six months. The corrosion rates in the second and third rows from the bottom are 31/64-inch and 19/64-inch per year, respectively. Life of the second row is about one year. Above this row tube life exceeds two years. All tubes are standard 900-pound steel pipe.

No. 3 Column Feed Plate Reboiler
The heaters in this service are similar to No. 2 column reboiler. Corrosion is maximum in the bottom (radiant) row, the average rate in this row being 48/64-inch per year. The corrosion rates in the second and third rows are 33/64-inch and 28/64-inch per year, respectively. All tubes are 900-pound steel pipe.

No. 3 Column Bottom Reboiler
The heaters in this service are similar to the No. 2 column reboiler furnaces. Corrosion is highest in the bottom (radiant) row. The rate varies widely from 6/64-inch to 36/64-inch per year, but the reason is unknown. In the second and third rows, corrosion rates vary similarly, ranging from 9/64-inch to 36/64-inch in the second row, and 6/64-inch to 24/64-inch in the third row.

Three 7-percent-chrome tubes installed in the bottom of this heater have been in service for three years, and no appreciable corrosion has occurred. The remaining tubes in the bottom row of this furnace are standard 900-pound steel pipe and have been replaced five times during the three-year period.

Heat Exchange Equipment

No. 1 Column Condenser
The unit consists of two steel shells in parallel. No significant shell corrosion has occurred.

The tube bundle is made up of ¾-inch, 14 B.W.G. admiralty* tubes, and an average life of 1 to 1½ years is experienced. There is some indication of poor vapor distribution due to the deposition of salts, and provisions are being made to wash the shell side with water. These units have been in service only two years, and the data available should not be considered final.

No. 2 Column Condenser
This unit consists of three shells in series. The top (hot) shell was lined with monel initially, but the center and bottom shells are steel. The corrosion rate is 4/64-inch and 1/64-inch per year, respectively, in

center and bottom shells. The monel-lined shell shows no sign of corrosive attack.

The tube bundles are constructed of ¾-inch, 14 B.W.G. admiralty tubes, with a minimum life of 18 months, and an average life of over two years.

No. 3 Column Vapor-to-Crude Exchanger

This exchanger is made up of four shells connected in two banks of two in series. The corrosion rate in the bottom shells varies from 1/64-inch to 6/64-inch per year, while the rate in the upper shells is somewhat less.

The life of ¾-inch, 14 B.W.G. admiralty bundles varies from 5 to 23 months, averaging about 11 months. It is estimated that steel bundles would last 3 months in this service.

No. 3 Tops Coolers

The shells are steel, and no appreciable corrosion has been encountered. Bundles made up of ¾-inch, 14 B.W.G. steel tubes have an average life of 25 months. Recently the bundles have been retubed with admiralty.*

*All admiralty tubes now used in the refinery contain arsenic, antimony, or phosphorus to reduce dezincification.

Residue-to-Crude Exchanger

The exchanger is composed of four units, connected in series, with steel shells, and tube bundles of ¾-inch, 14 B.W.G. steel tubes. Corrosion to the shells is slight. The hottest bundle (where residue is 650° F.) has a life of about 12 to 13 months. The other three bundles have been in service 4 years. "Croloy 7" tubes were installed in one bundle (the second exchanger in series, counting from the hot end) and have been in service 13 months. Recent inspections indicate they are still in good condition.

Process Piping

All process piping is steel. The maximum corrosion rate encountered in any of these lines is 12/64-inch per year.

SECTION II

Corrosion Experience—Cracking Units

THE data included in this section have been obtained from the operation of a 15,000-barrel-per-day two-coil selective cracking and continuous residuum coking unit. The unit, which consists of two parallel cracking sections and a two-furnace coking section, operates on a blend of reduced crudes of about 20 to 22 API gravity, containing 30 to 50 percent of West Texas stocks. The operating cycle is 60 to 70 days with about 3 to 5 days' downtime for inspection and maintenance between runs. On-stream time about 91 percent.

Lime is injected into the unit to reduce corrosion, the amount used being 0.4 to 0.5 pounds per barrel of topped crude charged. (It should be noted in this connection that lime has little effect where it does not actually contact the metal.) The method of injection is as follows: Hydrated lime is mixed with topped crude in two 2400-gallon tanks, agitated by a propeller-mixer located in the bottom of the tanks, to form a slurry containing 0.5 pound of lime per gallon of oil. The slurry is injected into the topped-crude stream on the downstream side of the centrifugal unit charge pump. Steel reciprocating pumps and displacement meters are used for handling and measuring the slurry.

Temperature has been found to exert an appreciable influence on the rate of corrosion. In the range of 700 to 800° F. corrosion is particularly severe, with the maximum rate occurring at about 750° F. Above and below this range, the attack decreases in severity.

Corrosion data are summarized below for the various items of equipment. All corrosion rates, unless otherwise noted, apply to operation when using lime. No ammonia is used on this cracking unit.

Light-Oil Furnaces and Lines

The furnaces are of Alcorn design, with radiant heating and soaking sections, and a central downflow convection section. During initial operation, severe corrosion was experienced in the steel convection tubes of this furnace, which charges a 660-end-point gasoil. Corrosion rates were 20/64-inch per year in the top (outlet) tubes and 11/64-inch per year in the bottom (inlet) tubes. Oil temperatures in the convection section are 600° F. inlet and 800° F. outlet. The steel tubes were replaced with 5-percent chrome, 0.5 percent moly. alloy, which has been very satisfactory; metal loss is only 1/64-inch per year.

The tubes in the radiant sections of the furnace are 5-percent-chrome, 0.5 moly. (original equipment) and corrosion has been very low (less than 1/64-inch per year in the roof soaking section, which operates in the temperature range 900 to 935° F.).

No serious corrosion has been observed in the steel light-oil hot-oil pump suction and discharge lines.

Heavy Oil Furnaces and Lines

These furnaces are of the Equiflux "Type A" design. Tube and line corrosion is severe in this section of the plant, and alloy is used to a considerable extent. The actual corrosion rates experienced are listed in Table 1. Since obtaining these data, the steel heavy-oil hot-oil pump block on the east cracking section has been replaced with 5-percent-chrome alloy block while the west section block was lined with 25-percent-chrome, 12 percent Ni-alloy. The pumps will be discussed further in a separate section on pump construction.

Coking Furnace and Lines

Corrosion rates on this equipment are relatively mild, as indicated in Table 2. In general, tube replacements in these furnaces are necessitated by swells, cracks and external oxidation rather than by corrosion.

Vessels

The cracking section main fractionators are steel and high corrosion rates were experienced during the initial period of operation as follows:

LOCATION	Approx. Temp.	Rate
At Bottom Baffle	735° F.	21/64 inch per year
Tray 5 (L. O. Drawoff)	600° F.	5/16 inch per year
Tray 11	500° F.	0.7/64 inch per year

A ganister liner was installed but proved unsatisfactory. Subsequently the ganister was replaced with a 12-percent-chrome liner (type 410) which extends upward to the bottom of the 11th tray (trays are numbered from bottom up).

The light-oil accumulators which operate at about 600° F. originally were steel. Corrosion was encountered at a rate of 4/64- to 6/64-inch per year, the maximum rate being observed in the center of the vessel. A brick liner was installed, but this proved unsatisfactory and was replaced with a type 410 liner.

The flash chambers on the cracking section are steel, originally metallized with .015-.02-inch of aluminum. The metallized coating was unsatisfactory and a 12-percent-chrome liner (type 410) was installed. The corrosion rate prior to the installation of the liner is not definitely known for the liner was installed as soon as corrosion was detected. This was required, since the vessel was operating at its maximum pressure rating. Operating temperatures are 840° F. bottom and 800° F. top.

The reaction chambers are steel with a metallized aluminum internal coating (.015-.020-inch). The metallized coating failed early in the operation of the unit but the steel vessel has not been seriously corroded in 8 years' operation. Operating temperature is 890-900° F.

The coke chambers are steel and were originally metallized with aluminum, which proved unsatisfactory. The maximum corrosion rate experienced was 12/64-inch per year at the top of the chambers, which operate at 850-860° F. The vessels are now lined with 12-percent-chrome (type 405) alloy.

The fractionator on the coking section originally was steel. Corrosion was experienced in the column as follows:

LOCATION*	Temp., °F.	Rate—Inches/Year
Tray 9	Approx. 500	2/64
Tray 3	Approx. 600	4/64
Bottom	800	6/64

* Trays numbered from bottom up.

The column is now lined with 12-percent-chrome alloy from the bottom up to tray No. 11. The liner, which originally was installed up to tray 3, has been extended as required by the corrosion experienced.

The stripping column on the coking section is fed from the 5th tray of the coking fractionator. The steel vessel corroded at a rate of 5/64-inch per year. A 12-percent-chrome alloy liner (type 410) is now in service.

TABLE 1

Corrosion Rates—Heavy Oil Furnaces, Pump and Lines

Dubbs No. 17	Material	Operating Temp.	CORROSION RATE (64th Inches/Year)			RATIO— (Corrosion without Lime/ Corrosion with Lime)		
			Prior 1939	1940–1941	1942–1943	Prior 1939	1940–1941	1942–1943
H. O. Furnace—Convection Tubes 1–12	5 percent Cr.	735–815	8.4	9.1	12	2.5	3.9	3.7
Convection Tubes 1–12	7 percent Cr.		....	....	6	....	....	3.7
Convection Tubes 13–24	5 percent Cr.		15.6	....	15	2.5	....	4.6
Convection Tubes 13–24	7 percent Cr.		None in Service					
Radiant Tubes.....25–40	5 percent Cr.	815–895	9.5	....	16	2.7	....	6.4
Radiant Tubes.....25–40	7 percent Cr.		....	....	8	....	....	6.4
Furnace Crossovers	7 percent Cr.		3.9	....	4	....	....	....
						2.5	3.1	
H. O. Pump Blocks	Steel	700–750	....	24.5	32	....	....	....
H. O. Suction Line Ex Fractionator	5 percent Cr.	700–750	9.9	5.4	..	3.9	....	....
H. O. Discharge Line to Furnace	5 percent Cr.	700–750	9.9	....	..	3.9	....	....
Vapor Line to Fractionator	5 percent Cr.	800–815	(Same as H.O. Furn. Conv. Tubes)					
Quench Suction Ex Fractionator	Steel	650–680	....	11.9	24	....	....	....

Heat-Exchange Equipment

The gasoline condensers on both the cracking and coking sections are of shell-and-tube design, with steel shells and admiralty tubes. No serious corrosion is experienced. Tube bundle life (1-inch, 12 B.W.G. tubes) averages 3 to 4 years on the cracking sections and 2 to 3 years on the coking sections.

Process Lines

Both the light-oil and heavy-oil transfer lines originally were 5-percent-chrome, 0.5 percent moly. piping. Corrosion is low—less than 1/64-inch per year. Operating temperatures are 980° F. and 900° F. respectively.

Metal loss in the drawoff line from the reaction chamber to flash chamber is high. Where steel pipe is used, rates as high as 11/64-inch per year are experienced. There are indications that this may be due as much to erosion as to corrosion. Some 5-percent- and 7-percent-chrome piping has been used with little advantage being noted over the use of steel. The temperature is about 875° F.

The residue drawoff line from the flash chamber originally was steel, and corrosion rates as high as 18/64-inch per year were experienced. Most of the steel pipe has been replaced with 5-percent-chrome alloy.

No corrosion difficulties have been encountered with the steel coking furnace transfer lines which operate at about 930° F. Rates are about 2/64-inch per year maximum, the average being about 1/64-inch.

Corrosion to the vapor line from the coke chambers to the fractionator (temperature 850° F.) is severe, metal loss averaging 12/64-inch per year (maximum 18/64-inch) with steel piping. Five-percent-chrome alloy is now used, and the corrosion rate is about 2.5/64-inch per year.

Steel tar-oil lines from the bottom of the coking fractionator, (temperature 800° F.) corrode at a rate of about 12/64-inch per year. Five-percent-chrome alloy is now used and losses are reduced to 3.6/64-inch per year.

Pumps

All hot-oil pumps are Worthington duplex, outside-end-packed, double-acting plunger pumps, with steel blocks and valve covers, heat-treated stainless-steel valves, valve seats and springs, and steel plungers with Janney alloy-steel jackets. Corrosion to the light-oil pump blocks has been light; however, the heavy-oil and coker blocks are severely attacked, the rates being about 24/64- and 32/64-inch per year, respectively. Recent data indicate rates of 60/64-inch per year in the latter. The increase has been attributed to the elimination of lime injection.

TABLE 2

Corrosion Rates—Coking Furnaces and Lines

	Operating Temp. °F.	Material	Corrosion Rate (Inches per Year)
Furnace "A" Coking Section (Equiflux Type A)			
Convection Tubes	800–850	5 percent Chrome	2.2/64
Radiant Tubes	850–950	Calorized 1¼ percent Cr.	1/64
Fittings	800–950	5 percent Chrome	1/64
Crossovers	850	5 percent Chrome	....
Furnace "B" Coking Section (Equiflux Type B)			
Convection Tubes	800–850	5 percent Chrome	3.4/64
Radiant Tubes	850–950	Calorized 1¼ inch Cr.	3.0/64
Fittings	850	9 percent Cr.	....

The hot oil pump suction and discharge lines are 5-percent-chrome steel and corroded at a rate of about 2/64-inch per year.

In order to reduce the corrosion experienced in the heavy-oil blocks, a 5-percent-chrome block was installed on the east section, while the west section block was lined with 25-12-percent-chrome Ni-steel by depositing weld metal in the block. As yet, no data are available to indicate how successful this lining method has been.

Inspection of pump blocks is a difficult task, since the maximum corrosion occurs internally across the web dividing the plunger chambers, and between the valve seats and plunger chamber, where the steel is subject to corrosion on both sides. Special calipers have been designed to inspect these regions. Failure at any of these points is not a safety hazard, of course, but does render the pump inoperative due to internal bypassing of the liquid.

Plunger liners are now made at the refinery machine shop, by shrinking 14-16-percent-chrome sleeves (heat treated to 450-500 Brinell) on the plungers. The original steel valve covers have been provided with a 12-percent-chrome alloy (type 410) tapered sleeve cover.

Two Worthington 6-inch x 12-inch duplex piston pumps in quench-oil service (operating temperature 700° F.) originally were equipped with steel liquid ends. Corrosion was severe (5/64-12/64-inch per year), and the blocks have been replaced with 5-percent-chrome alloy.

The hot-residue pumps charging the coking section are steel reciprocating pumps. Cracked-gasoline reflux pumps are centrifugal with cast semi-steel case and impeller.

Storage Tanks

Corrosion to storage tanks occurs primarily in two locations; the roof and the tank bottom and lower ring. Actual corrosion rates are available only for storage tanks handling West Texas reduced crude and cracked residue. Rates in both these services are 2/64-inch to 3/64-inch per year for roof plates and about 1/64-inch per year for side plates. Experience indicates that crude-tank corrosion rates are not much greater than those encountered in residue service.

Relative Corrosion Rate and Relative Cost of Alloys

The relative corrosion rate for steel and various alloys was determined on a straight-run-naphtha reforming furnace charging West Texas naphtha. The results are included in Table 3, together with data published by National Tube Company. These data have been found to apply to cracking processes in general without excessive error. The approximate relative cost of the alloys is included for comparison.

In general, 5-percent-chrome, 0.5-percent-moly. steel is being used for furnace tubes and lines, except in a few locations where higher chrome contents are economical. Furnace return bends usually are installed with higher chromium content than the tubes; i.e., 7-percent return bends with

TABLE 3

Relative Corrosion Rate for Alloys

MATERIAL	Relative Corrosion Rate		Relative Cost*
	Shell Data	Natl. Tube Data	
Low Carbon Steel	1.00	1.00	1.00
5 percent Chrome, 0.5 percent Moly	0.38	0.28	3.30
7 percent Chrome, 0.5 percent Moly	0.17	0.23	3.70
9 percent Chrome, 1.5 percent Moly	0.11	0.19	....
8 percent Chrome, 1 percent Moly	....	....	4.35
18 percent Chrome, 8 percent Ni-Ti	....	....	14.49

* Based on data in National Tube Company Bulletin No. 26 (Revised 1942).

TABLE 4

PUMP SERVICE	Reduced Crude Charge	Cracker H. P. Quench	Cracker L. P. Quench	Coker Charge	Gasoline Reflux
Temperature, °F	300	650	560	790	120
Case	cast steel	11.5%-13% chrome	cast steel	11.5%-13% chrome	cast steel
Case Wear Ring	nickel cast iron	11.5%-13% chrome	11.5%-13% chrome	11.5%-13% chrome	nickel cast iron
Impeller	nickel cast iron	11.5%-13% chrome	11.5%-13% chrome	11.5%-13% chrome	nickel cast iron
Impeller Wear Rings	11.5%-13% chrome	11.5%-13% chrome	11.5%-13% chrome stellited	11.5%-13% chrome stellited	case-hardened steel
Shaft	SAE 3440 H.T. steel	11.5%-13% chrome	11.5%-13% chrome	11.5%-13% chrome	SAE 2330 H.T. steel
Shaft Sleeves	11.5%-13% chrome 350 Brinell	11.5%-13% chrome	11.5%-13% chrome stellited	11.5%-13% chrome stellited	11.5%-13% chrome

5-percent tubes, 9-percent return bends with 7-percent tubes. This has been done to avoid frequent replacement of return bends since two tubes must be destroyed to replace a bend.

Liners now in service are exclusively 12-percent-chrome alloys. The higher cost of these alloys is justified by the high installation labor cost and reduction of downtime on the unit, both of which favor the use of those alloys which are sufficiently resistant to avoid frequent liner repairs and renewals.

Ganister and brick liners were installed in the main fractionator and strippers, respectively, but cracking and spalling were experienced and maintenance was excessive.

Field resistance-welded stainless (14-percent-chrome) liners have been tried, and found to be unsatisfactory; excessive cracking and buckling of the liner was experienced, which permitted corrosion to the vessel behind the liner.

The following vessels are now protected with plug-welded strip liners; cracking main fractionators, cracking flash chambers, cracking L.O. strippers, coking fractionator, coking stripper and coke chambers. The coke chamber installations, which are in the most severe service from the standpoint of buckling due to temperature variations, have been in place up to 4 years, with satisfactory results. These installations employed type 405 strips, 0.109-inch thick and 3 inches wide, having ⅞-inch-diameter plug welds on 1½-inch centers. The selection of strip- and plug-weld dimensions are based on the results of extensive tests conducted by A. O. Smith Corporation. These tests duplicated insofar as practicable the temperature cycles in our coking operations, and proved rather conclusively that plug welds were necessary to provide adequate heat transfer from the liner to the vessel wall to reduce differential expansion during temperature changes in the coking cycle.

Units Designed for West Texas Operation

An 18,000-barrel-per-day once-through cracking and continuous-coking unit is in service in this refinery, operating on 100 percent West Texas reduced crude. This unit, which was designed to handle West Texas reduced crude, was provided with 7-percent-chrome alloy furnace tubes and 12-percent-chrome alloy lined columns. No corrosion difficulties have been experienced.

A quench-oil heat-exchanger installation preheating reduced crude charge to this unit was equipped with steel tubes. The average life is less than 2 years. Replacements are now being made with 5-percent-chrome alloy tubes. Quench-oil temperatures are 665° F. inlet and 475° F. outlet; reduced crude temperatures are 375° F. inlet and 460° F. outlet.

Condenser bundles have ¾-inch, 14 B.W.G. admiralty tubes. No hydrocarbon-side corrosion is encountered. (It is standard practice to use Muntz metal or naval brass tube sheets with admiralty tubes.)

Typical pump specifications at this unit are listed in Table 4. Liberal use of alloy is made to resist corrosion.

Effect of Salt in Reduced Crude on Corrosion

Some evidence has been obtained to show the effect of salt in the topped crude on the corrosion experienced in cracking operations. This will be discussed in the section on desalting of crude oil.

SECTION III

Desalting Crude Oils

DESALTING operations at this refinery have been confined primarily to two crudes, West Texas and Kansas-Healdton. Operation on the former crude is consistently good and has been standardized. The results obtained on Kansas-Healdton are not as satisfactory, and the operating procedure is still undergoing development.

West Texas crude charged consists of a mixture of Southwestern crude, of which the following composition is typical:

	Percent
Natural gasoline	6.6
New Mexico	23.9
West Texas	63.2
North Texas	2.7
Wildcat Jim	3.6

The method of desalting consists of contacting the crude with water, followed by hot settling under pressure. Under the conditions employed, a salt removal of about 85 percent is regularly obtained, the salt content of the washer crude being about 10 pounds per 1000 barrels.

Equipment

Two 35,000-barrels-per-day three-column topping units are equipped with desalting facilities, which include the following items of equipment:

1. Three vertical salt settlers, each 10 x 40 feet equipped with an oil-distributor spider, and trylines. Each distributor is constructed of four parallel horizontal sections of 3-inch pipe connected to a 6-inch header, drilled with 1-inch holes on 1¾-inch centers looking up alternately to right and to left at an angle of 30 degrees from the vertical. Trylines are provided on each settler, located on 2½- to 3-foot centers.
2. Water-injection pump.
3. Caustic-injection pump.
4. Brine-recirculation pump (on one unit only).
5. Mixers for contacting the crude with water. Duriron, Hi-Hat, and globe valve mixers have been used.

The flow through the system is as follows: Crude oil is preheated in heat exchangers to a temperature of 220-240° F., after which water and caustic solution are injected into the crude stream ahead of the mixers. Following the mixers, the crude-water emulsion enters the settlers through the distributor. (A brine level of 24-27 feet is maintained in the settler, so that the distributor is located 21-24 feet below the water-oil interface.) Desalted oil flows out the top of the settler, while brine is drained from the bottom of the vessel using a Hancock "Flo-Control" valve to control the brine-oil interface.

Factors Affecting Desalting of West Texas Crude

Salt is present in crude oils in two forms: (1) As brine droplets dispersed in the oil, and (2) as microscopic particles of solid salt. Both forms are frequently protected by a layer of wax or natural emulsifying agent in the crude. In order to remove the salt, it is necessary to mix intimately the crude oil with water, forming an emulsion, which then must be broken in the settling vessel. Several factors are of importance in the two operations, and are considered below. It is emphasized that these results apply primarily to West Texas crude. Variations in procedure necessary for desalting of other crude will be considered in a separate section.

(A) *Intimacy of Mixing*

Approximately 30 pounds pressure drop across the mixers appears to be optimum for maximum salt removal. Higher pressure drops result in the formation of more stable emulsions, which are difficult to break; lower pressure drops do not disperse the water injected sufficiently, and desalting efficiency is reduced.

(B) *Volume of Water Injected*

Normally the water-injection rate amounts to about 2.5 percent of the crude, although the actual value is dependent on the salt content of the crude, and the brine concentration maintained. The latter will be discussed below.

Brine recirculation facilities were provided in the original installation (to permit recycling up to 20 percent of brine), but have been found unnecessary. Actually somewhat higher

salt removal efficiencies were obtained immediately after recirculation was discontinued, although this may be partially accounted for by an increase in the temperature in the salt settlers which occurred at the same time.

(C) *Position of Water-Oil Interface Relative to the Oil Injection Point*

Injection of the emulsified water and oil into the aqueous phase has been found to be essential to good desalting. The position of the interface exerts a considerable influence on the results obtained, as indicated by the data shown in Table 5.

Further development work indicated that most satisfactory operation resulted when the brine-oil interface is maintained about 20-25 feet above the oil-injection point. This indicates that demulsification occurs largely during the passage of the oil droplets through the aqueous phase.

The position of the brine-oil interface is considered to be that point where appreciable oil has started to separate. Actually the crude at higher levels contains considerable quantities of water, as shown in Table 6. For the case shown, the interface is said to be 8 to 9 feet above the inlet.

(D) *Brine Concentration*

Operating experience indicates that a brine concentration of 2.5-4.0 pounds salt per barrel of brine is desirable for maximum salt removal and minimum water consumption. This is shown by data in Table 7. The improved salt removal obtained may be attributed to two factors: (1) Stronger brines contain higher concentrations of those demulsifiers which occur naturally in the crude and which are extracted by the caustic soda injected into the crude and (2) a greater differential in specific gravities of the salt solution and the crude.

(E) *Effect of pH of Brine*

The pH of the brine should be maintained at a relatively high value (8.0 to 9.0 is about optimum) by the injection of 5° Be′ caustic soda solution into the crude stream ahead of the mixers. Caustic consumption is low (about 0.01 pound per barrel of crude, or less) and the higher pH, in addition to improving salt removal, tends to reduce corrosion to the salt settlers. Partially spent soda from straight-run naphtha scrubbers (for removing H_2S) can be used without deleterious effect to desalting efficiency.

(F) *Operating Temperature*

Temperatures of at least 200° F. should be maintained in the salt settlers, and 250° F. is highly desirable, since the higher temperature is of value in breaking emulsions. At present the settlers at this refinery operate in the range of 220-240° F.

(G) *Operating Pressure*

The pressure is not a vital consideration. It is only necessary that the pressure be maintained high enough to avoid appreciable vaporization. The operating pressure used at this refinery is about 150 pounds per square inch.

(H) *Residence Time*

High residence times are of value in obtaining maximum salt removal. The data included in Table 8 will illustrate this effect. It is recommended that the throughput be limited to 500 barrels per hour per settler for 10 x 40 feet settlers. Vessels of other sizes may be used, but the throughput should be limited in proportion to the available residence time for the oil. Vertical vessels of smaller diameter have not been used, and no data are available concerning their efficiency. With vessels of very small diameter, the vertical oil velocity may increase sufficiently to reduce appreciably the rate of settling of the water, and, consequently, salt removal.

Of course, other methods of coalescing the dispersed water have been proposed, among which are the following:

(1) Gentle Agitation. This is carried out by passing the oil-water emulsion through long pipes at relatively low velocity. The mixture is introduced into a settling vessel to permit separation of the two phases.

(2) Solid Contact. This method utilizes a vessel packed with Raschig rings, steel wool, glass wool, excelsior or similar material to coalesce the water. Final separation occurs in a settling vessel which follows.

(3) Centrifugal. The dispersed brine may be removed by centrifuging the crude oil.

The first of these methods is recommended by certain suppliers of proprietary treating agents and demulsifiers for salt removal. The second has been used successfully for coalescing water and treating agents in other products but we have had no experience with them in the desalting of crude.

(I) *Accumulation of Solids at Water-Oil Interface*

Erratic operation in the past has been traced to an accumulation of solids (primarily sand and tank scale) at the water-oil interface, which stabilizes the water-oil emulsion, resulting in high water entrainment, and poor salt removal. The difficulty can be eliminated by bypassing the settler and draining the interface material through the trylines.

TABLE 5

Effect of Interface Location on Salt Removal

Height of Interface above Oil Inlet—Feet	Salt Removal Percent
2	35
5	85

TABLE 6

Water Gradient in Salt Settler

Distance Below Inlet—Feet	Distance Above Inlet—Feet	Water %v
1½	....	100
4	....	100
	1½	95-98%
	4	
	6½	
	9	80
	11½	70
	14	50
	16½	35

TABLE 7

Effect of Brine Concentration on Salt Removal

Salt Content of Brine Lb. Salt/Bbl.	Salt Content of Washed Crude Lb./M. Barrels	Water Content of Washed Crude Percent
.08	41	2.5
.11	25	0.7
.16	16	0.5
.19	15	0.5
.26	11	0.2
2.07	12	0.3
2.32	9	0.2
2.62	10	0.3
3.51	8	0.3
4.66	12	0.1
5.27	15	0.2
7.20	26	0.4

TABLE 8

Effect of Residence Time on Salt Removal

Thruput Bbl./Hr./Settler	Salt Contents—Lb./M. Barrel	
	Crude Charge	Desalted Crude
510	59	6
600	59	16
675	59	23

TABLE 9

Crude Intake—Bbl./Hr./Settler	485
Height of Interface above Injection Point—Feet	21
Temp. at Inlet to Settler—F	230
Water Injection—%v of Crude	2.5
Brine Circulation—%v of Crude	None
pH of Brine	8.5
Brine Concentration—Lb. Salt/Bbl	3.13
Settler Pressure—psig	160
Water Content of Crude—%v	0.1
Water Content of Washed Crude—%v	0.1
Salt Content of Crude—Lb./M. Bbl	90
Salt Content of Washed Crude—Lb./M. Bbl	10

(J) *Initial Salt Content of the Crude*

The salt content of the washed crude is not appreciably affected by the salt content of the crude charged. Within the range of 50-100 pounds of salt per thousand barrels of raw crude, the salt content of the washed crude remains constant at about 10-12 lb./M barrels.

(K) *Oil in Effluent Brine*

No difficulty has been experienced with oil entrainment in the brine drained from the salt settlers; the oil content of the brine is consistently in the range of .003 to .007 percent. The brine is drained directly to the sewer without further treatment.

(L) *Typical Operating Results*

Table 9 is included to show typical operating data when desalting West Texas crude. These data are representative of daily routine operating results at the present time.

Desalting Kansas-Healdton Crude

Experience has shown that Kansas-Healdton crude can-

not be satisfactorily desalted using the procedure applied to West Texas. Mixing immediately preceding the salt settlers resulted in the formation of a relatively stable emulsion, with consequent high water carryover and poor salt removal.

Recently, favorable results have been obtained by recirculation of brine without fresh water injection (caustic is injected, of course, to maintain the pH). The brine is injected into the crude stream ahead of the five heat exchangers in series. The brine-oil mixture is gently agitated by the turbulence resulting from the passage through the heat exchangers, and no additional mixing is provided ahead of the settlers. Some water emulsified in the crude charge is removed and the salt content of the brine increases during the run. Since the topping unit is operated alternately on West Texas and Kansas-Healdton crudes, this procedure is feasible; the brine concentration is reduced to normal by water injection during West Texas runs.

Use of Demulsifiers

Some tests have been made of commercial demulsifiers for crudes other than West Texas, however, we have not found it necessary to apply these materials to our West Texas crudes.

Corrosion to Salt Settlers

Corrosion to the salt settlers is confined primarily to the bottom head and bottom shell region, where maximum rates of 11/64-inch per year and 7/64-inch per year have been experienced. The corrosion appears to be the result of oxygen attack, accelerated by sulfide in the presence of water. Oxygen enters dissolved in the water injected, while sulfide is due to H_2S present in the crude.

A ¾-inch ganister liner (Lumnite cement and ground brick ganister) has been installed in all salt settlers. Performance of the liner has been satisfactory. No deterioration of the cement has been observed in more than two years of service.

Analytical Methods

The water content in the crude oil is determined by the standard ASTM distillation procedure.

Salt in crude oil is determined as follows:

To 200 cc of crude oil are added, in order, 30 cc alcohol, 30 cc acetone, 50 cc benzol, and 200 cc distilled water. The mixture is shaken after each addition, and 15-20 minutes after the water is added. Occasionally more benzol is required to break emulsions.

A 50 cc aliquot of the aqueous layer is titrated with standard silver nitrate (0.1N for high concentrations, 0.01N for low concentrations) using potassium chromate indicator. Results are reported by calculating the chloride so determined as pounds NaCl per thousand barrels crude. Note that in the calculations, allowance should be made for the alcohol and acetone, both of which are present in the aqueous layer.

Salt in brine is determined by direct titration of the brine with standard silver nitrate and potassium chromate indicator. Results are reported as pounds NaCl per barrel of brine.

Justification for Salt Removal

Justification for desalting can be summarized under two major groups: Reduction of corrosion, and reduction of cleaning of furnaces, heat exchangers and distillation equipment. Admittedly, the exact effects of desalting may vary widely in different refineries, depending on a large number of equipment design and operating factors; nevertheless, these results should be of advantage for a preliminary estimate of profitability.

Maintainence cleaning costs on heat exchangers are definitely reduced by salt removal. On topping units it was found that desalting reduced the cleaning cycle for the residue to crude-oil heat exchangers from 4 to 8 weeks to 8 to 12 months. No advantage is gained in the other heat exchangers since these are used to preheat the crude prior to desalting.

A reduction in cracking-tube deposition can also be claimed. No exact data are available, but indications are that a considerable portion of the tube deposit is salt. The effect is exaggerated when an alkaline agent is injected into the cracking unit charge to reduce corrosion. When using soda ash as a corrosion inhibitor (0.5 pound per barrel) at a cracking plant, the heavy-oil furnace run length was reduced from a normal of 60 to 70 days to 30 days as a result of soda ash injection. The salt content of the topped crude charged at the time of this test was about 100 pounds per thousand barrels of topped crude. The solids remaining in the tube after steam-air decoking were 80 percent water soluble, of which ⅓ was soda ash, and ⅔ salts normally found in crude oils (NaCl, $CaCl_2$, etc.). No data are available to indicate the effect of salt alone; however, when charging residues of much higher salt content, or when operating for runs longer than 60 days the effect may be appreciable.

Desalting crude oils reduces corrosion in both topping and cracking units. Not only are salt solutions corrosive to steel of themselves, but at elevated temperatures certain chlorides, principally magnesium chloride, hydrolyze forming HCl, which is extremely corrosive, especially in condensers and other similar locations where it comes in contact with liquid water. (A summary of the corrosive action of salt, as well as desalting methods may be found in the Bureau of Mines Report R.I. 3422—"Desalting Crude Petroleum—A Review of the Literature".)

On topping units a reduction of heater tube corrosion of 27 percent was attributed to desalting. No data are available to indicate the effect on process lines and vessels; however, it is felt that desalting will be of some value here. It should be noted that these results are based on use of carbon-steel pipe. Alloy piping is used at the topping units to only a limited degree, and no evaluation of its resistance to salt attack can be made.

On cracking units it has been found that desalting reduces corrosion of the heavy-oil furnace tubes some 35 percent. This applies to the use of 5-percent-chrome, 0.5 percent molybdenum tubes. Lime injection (0.5 pound per barrel charge) was employed during the entire test period. Under the same conditions, a reduction of 23 percent was observed in coker-furnace-tube corrosion rates.

Some data are available to indicate the effect of desalting on steel cracking tubes without lime injection. A 50 percent reduction was observed in this case following the inauguration of crude desalting. The data were obtained at different times, however, and should be used with some reservations, especially since the ratio of sweet to sour stocks in the residue charged to the cracking unit increased during the test period.

No information is available to show the effect of desalting on process line and vessel corrosion in cracking plants. Undoubtedly a reduction occurs; however, a quantitative evaluation of the advantages of desalting has not been possible.

In addition, desalting of crude oils produces residual fuel oil of a lower B.S.&W. and ash content, asphalts of a higher CCl_4 and CS_2 solubility, and coke of lower ash content. Evaluation of these factors must, of course, be applied to each refinery separately.

SECTION IV

Maintenance and Safety Practices

THE chief hazards involved in the processing of sour crudes are asphyxiation by H_2S vapors, and fires caused by the spontaneous ignition of pyrophoric iron sulfide upon exposure to air. The former hazard is avoided by the use of gas masks in any location where high concentrations of H_2S exist. The latter hazard occurs in tube bundles and tanks, especially those handling light distillates, such as gasolines and naphthas, containing H_2S. This hazard can be eliminated to a considerable degree by treating to remove H_2S as soon as practicable in the process system. This is done on the topping units where straight-run gasoline and straight-run naphtha are caustic scrubbed before leaving the units. The caustic scrubbing has the additional advantage of reducing corrosion to lines, tanks, etc.

Gas masks used in the refinery are of three types. Canister type gas masks fitted with canisters for hydrocarbon and acid gases are used most frequently for general service, such as gauging and sampling crude and other tanks from which H_2S fumes are evolved. Blower masks (hose masks) are used for prolonged work in gaseous or oxygen deficient atmospheres. The blower supplying air is hand-operated for maximum reliability. Oxygen masks are also available for work in oxygen deficient or gaseous atmospheres. These are used instead of blower masks when the time required is relatively short, since less equipment must be moved to the job site. These masks will furnish oxygen for at least one hour.

All respiratory equipment used should have United States Bureau of Mines approval.

H_2S is qualitatively determined by the use of lead acetate paper. Where any question of concentration exists, a hydrogen sulfide indicator is used.

Routine operating and maintenance practices have been established and are discussed below. The procedures used

when opening vessels for inspection and maintenance are standard, and no distinction is made between sweet and sour crudes.

Handling West Texas Crude

Since all crudes are received in this refinery by pipe line, the operating problems involved in handling sour crude are restricted to gauging and sampling tanks. Each tank gauger is issued a gas mask for use with West Texas crude tanks. In cases where H_2S is especially severe, it is required that no man ascend to the top of the tank unless another man is nearby to aid in case of emergency. Warning signs are placed at or near the ladder or stairway on each tank containing West Texas crude. These precautions are also taken on product tanks storing oils from which H_2S is or may be evolved.

Warning signs should also be placed at sewer boxes and similar equipment from which H_2S may be released.

Sour crude was received at this refinery in tank cars a number of years ago. Precautions were similar to the above in that each operator was provided with a gas mask for use when opening hatches and gauging cars. In other respects, normal tank-car unloading procedures were followed.

Fractionating Towers

Topping-unit fractionators following shutdown of the unit are steamed from the bottom for two hours, with water condensate drained from the tops receiver to the sewer. Water is then introduced into the top of the column through the reflux line and the column washed until no trace of oil is evident in the water drained from the bottom. This usually requires about four hours. When the water wash is complete, the top manhole is opened and a steam aspirator is placed in the manway. Steam is again introduced into the base of the column for 1½ hours, after which the bottom manhole is opened and the column is cooled by air circulation induced by the steam aspirator. During this period blinds are placed in all lines entering or leaving the column. Before maintenance crews enter the vessel the atmosphere is tested for combustible gases, using a combustible gas indicator calibrated for methane. Cases where the above procedure has failed to render the column gasfree are very infrequent. Of course, any column which is free of combustible gases is free of H_2S.

The procedure used at the cracking plants is slightly different. The column after being drained, is steamed for 1½ hours, after which water is introduced into the base of the column and oil floated out overhead. (The coke-chamber-cooling pumps and facilities are used for this purpose.) If maintenance work is to be done to the condensers, the water is allowed to overflow through the vapor line for ½ hour to wash the bundle. The fractionator is then drained, manholes opened and a steam aspirator placed in the top manway. All lines are blinded and the atmosphere tested for gas in the same manner as topping columns.

The major reason for the variation in procedure is the availability of existing facilities for filling the cracking unit columns.

Other Vessels

Salt settlers and similar vessels not equipped with internal trays or baffling, at the topping units are drained through the dropout line, after which the top head is opened and the vessel steamed to the atmosphere. The bottom manhole is then opened, an aspirator is placed at the top manhole and the vessel cooled by air circulation.

Reaction chambers, flash chambers and similar cracking-unit vessels are steamed out for 1 hour through the pressure drain line to the cracking-unit blowoff pits. Water from the coke-chamber-cooling system is introduced into the vessel and discharged to the blowoff pits. Water circulation is continued until the vessel temperature drops to 150° F., after which the vessel is opened. Steam aspirators are placed, and the vessel is blinded and tested for gas as above. Four to 6 hours are required to cool the vessels in this manner.

Coke chambers are steamed from the bottom for an hour, after which water is introduced into the bottom of the chamber to cool the coke bed. About 6 hours are required to cool a 13- by 50-foot chamber. The atmosphere is tested for gas as soon as the top head is opened. No aspirators are used since the chambers are decoked hydraulically, and it is not necessary for men to enter the vessel.

Furnace Tubes

Topping heaters are normally "circulated" down. After cutting fires, cold residue is charged from a storage tank to the heater through the circulating manifold. The hot residue from the heater outlet returns through a dropout cooler to the storage tank. When the outlet temperature of the residue reaches 300° F., circulation is discontinued, and the heater tubes are steamed for 2 hours, after which they are opened for cleaning and inspection.

Cracking-heater tubes are dropped out as soon as fires are cut, and steamed for 2 hours, after which they are opened.

Tanks

Tanks are pumped out through the waterdraw, followed by water to float the remaining hydrocarbon, and the liquid drawn to the sewer. Steam is introduced and continued until the tank is vapor free. Aspirators are placed in roof manways to induce ventilation. If B.S. is present, blower masks are used by men working in the tank until the sludge deposit has been shoveled out. All rafters and horizontal surfaces in tanks in sour naphtha or gasoline service are thoroughly cleaned to remove iron sulfide (which may be pyrophoric). On other tanks, cleaning is usually confined to the bottom of the tank, unless inspection work is to be done.

Tube bundles in gasoline and naphtha service frequently contain pyrophoric iron sulfide. Fires from this source can prove very serious. Cases are known in which the tube bundle was completely destroyed by fires resulting from spontaneous ignition of sulfides. Water hoses played on the bundle as it is pulled from the shell will eliminate this hazard. The exchangers should, of course, be flushed with water before opening.

Tank fires have been known to be caused by the combustion of pyrophoric iron sulfide. Floating roof tanks are most susceptible, since the lowering of the roof as the tank drops to low gauge exposes tank-wall surfaces to the atmosphere. The hazard can be reduced by maintaining roof seals in good condition.

Disposal of Spent Chemicals

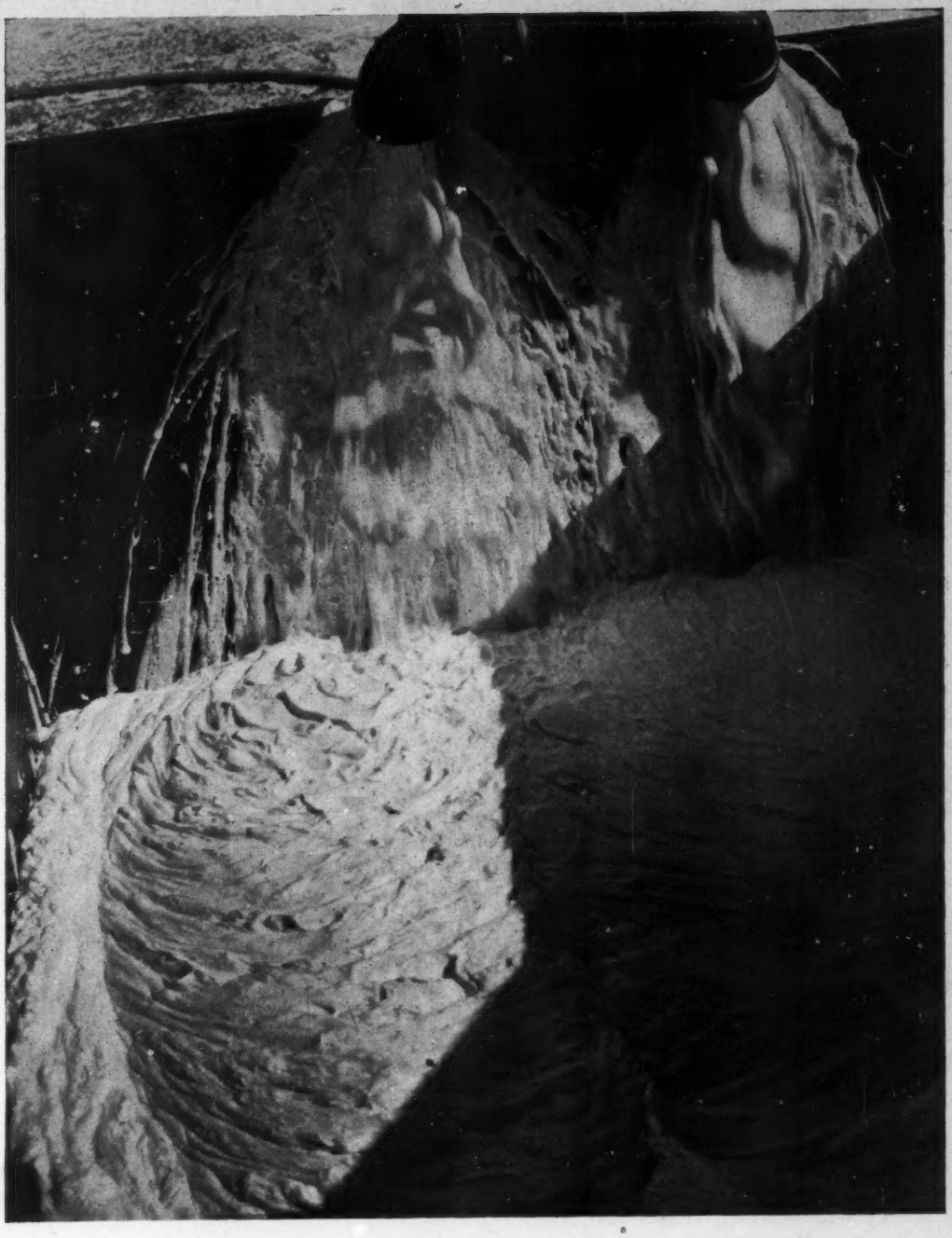
In the refining of West Texas crude, sulfuric acid and caustic soda are utilized for sulfur reduction and H_2S removal. Disposal of the spent chemicals may prove to be a problem. Sodium sulfide solutions and acidic wastes should not be permitted to mix in the sewer system because of the release of H_2S which would result. One solution is the installation of a separate drainage system for spent caustic solutions. The alternate to this is to schedule drainage of chemicals to the sewer. In a typical system of this type, caustic wastes may be drained during the first two hours of each shift and acid during the fifth and sixth hours. During the second and fourth two-hour periods chemical draining is prohibited. In these periods, the sewer system is washed free of chemical waste. This schedule should be modified to suit the particular conditions at any refinery.

Any mercaptans present in spent sodas should be removed before discharging to the sewer. This can be done by steam stripping the spent solution. Direct injection of exhaust steam into a packed or plate column is satisfactory. The vapors from the top of the stripper may be vented to a nearby heater for disposal.

In some cases, the discharge of sulfide spent caustic itself may be undesirable, especially if the stream to which wastes are discharged is the source of supply of a domestic water plant. Small amounts of sodium sulfide are not serious, of course, but large amounts may impart an undesirable taste to the drinking water. If this situation exists it may be necessary to install neutralizing facilities for sulfide spent caustics. Acid sludge can be used as the neutralizing agent, thus converting the sulfide salts to sodium sulfate. The H_2S gas produced is vented to a heater where it may be used as fuel. The oil released from the acid sludge is recovered and used as refinery fuel. In operating this system, the aqueous solution from the neutralizer is maintained at ½ to 1 percent free acid. Homogeneous lead lining is recommended for the neutralizing vessel, although a monel-lined steel vessel is also suitable.

If the spent caustics contain appreciable quantities of acid oils (alkyl phenols) the effect on drinking water supplies becomes extremely serious, since phenols, after chlorination in water plants, are distasteful, and may be detected in concentrations of one part in one billion of water. Neutralization of phenolic wastes is necessary in this case, and settling of the aqueous layer in lead-lined tanks is recommended in order to eliminate all acid oils entrained in the weak acid prior to draining to the sewer.

Acid sludge can be disposed of in three ways: burning under boilers, burning in sludge ponds located well away from the refining area, and acid-recovery units, which produce fresh acid for process use. The first two methods are used at this refinery. Burning of the sludge is carried out in a Duncan sludge burner.



Application of foam into tank by header

F. S. MABBATT
National Foam
Systems, Inc.

How Foam Conquors Fire

DEVELOPMENT of foam as a fire-extinguishing medium for oil fires must be credited, largely, to the oil industry itself as, prior to the first foam apparatus on the market, several of the oil companies had employed the basic principle of foam, and had experimented with its use. Prior to this time, steam smothering systems had been used but were considered of limited value. During this period it was standard practice to maintain empty tanks in all oil plants so that if one tank caught fire its contents could be pumped into an empty tank. If fire occurred on the ground it was only possible to delay its flow and confine it, insofar as possible, to its original area. The fire in either case continued to burn until the product was exhausted.

The original foam system installations were commonly termed "wet systems." Such installations were cumbersome, expensive and presented a constant maintenance problem, although when properly designed and installed, they served a very valuable purpose. However, there are inherent disadvantages to this type of installation in that it is impossible to concentrate a large volume of foam at one point in the plant, and further the solution storage capacity is often inadequate for fires covering great areas or a number of tanks. Once the chemical solutions are

exhausted the system has to be shut down for a period of hours while the solutions are being replenished. In this time the fire may have regained its original intensity.

The most valuable development in the art of foam fire protection was the development of the dry powder foam generator method. As the reserve chemical with this type of system is in powder form and stored in pails, this type of installation had great flexibility and, so long as additional chemicals can be brought in, has no definite time limit. In other words, the generators can be operated continuously so long as chemical can be shipped to the point of the fire from adjacent plants or emergency storage.

The operation of dry powder foam equipment is essentially simple. However, there are a few points which are of utmost importance which should be taught to every man having any connection with the fighting of fires in oil plants. These points are as follows:

1. *Rate of delivery of foam.* This is probably the most important consideration and governs the number and size of generators necessary, volume and pressure of water supply required and number of men needed. In this connection, a safe minimum is 1/10 cubic foot of foam per square foot of oil area per minute. This figure presupposes the destruction by fire, updraft, etc., of a portion of the foam, and it does not mean that there will be foam one foot deep over the entire area after the fire is extinguished. It is extremely important on fires covering large areas to wait until sufficient equipment is on hand and ready to be operated before delivering any foam to the fire as, at an insufficient delivery rate all of the foam may be consumed and none of the fire extinguished. In this case, fighting an oil fire differs from fires in ordinary combustible material where one stream can accomplish part of the job while others are being brought to bear.

2. *Chemial required.* Total amount of chemical to be kept on hand depends to some extent on local conditions. Quantities are outlined by the National Board of Fire Underwriters and are considered safe minimums. As these prescribed amounts of chemical are based on average conditions, there will be cases where, if there are other refining plants in the vicinity each of which has a reasonable amount of chemical in storage, the amount prescribed may be reduced. If, on the other hand, the plant is isolated and the risk of considerable size, an increase in average amounts would be advisable.

3. *Methods of application vary.* In many instances foam delivery chambers are attached to tanks with lines running either to mains from foam house or to a point outside of dikes or other safe location, with provision made for attachment of hose lines from generators. In these cases, extinguishment of a tank fire is comparatively simple. It is important that sufficient chemical be on hand before starting operation to assure continued operation of all generators for at least 10 minutes. Hauling chemical to the point of operation should not be stopped until sufficient chemical is on hand for 20 minutes of operation even though the additional 10 minutes supply may not be needed. Cans should not be opened except a sufficient number to keep ahead of the operators so that there will be no interruption in supplying generators.

4. *Portable towers.* In many cases where foam delivery chambers are not installed, portable foam towers may be employed. The same precautions previously mentioned should be kept in mind when using foam towers.

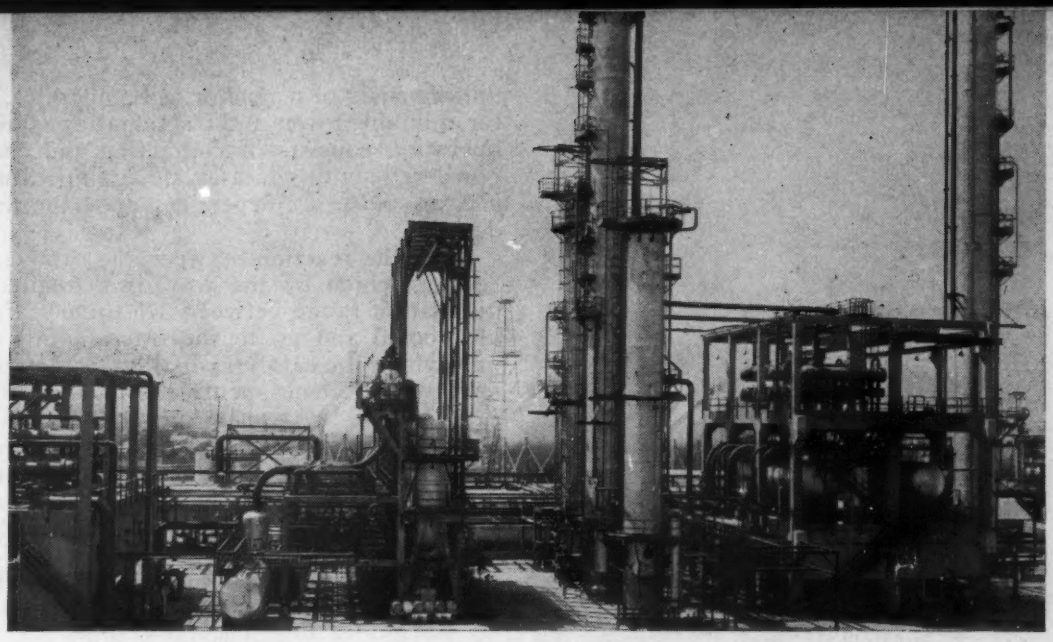
5. *Foam hose streams.* Many tanks have been extinguished by means of hose streams where no delivery chambers or portable towers were installed. However, this method of extinguishment is somewhat more difficult. It is also important in this type of operation to direct the stream against the far side of the inside of the tank shell so that the product in the tank will not be unduly agitated as would be the case if a stream of foam were to be directed on to the liquid surface.

6. *Foam hose streams on ground fires.* In this type of fire the same precaution should be taken in directing the foam stream as in fighting tank fires. The stream should not be directed into the burning area but deflected against some obstruction in the area such as tank shell, dike wall, etc. In such cases, it is not always necessary to apply as much foam as would be required through foam chambers, as the operators can direct the foam streams and thus cover the entire area with less foam. This is also true of rate of delivery. This is borne out by the fact that the National Board of Fire Underwriters considers that generator or generators adequate for a tank, through foam chambers, will also be adequate for the dike area around the tank.

7. *Open fires.* In fighting fires in open drains, sumps and pits, where the product is flowing, it is preferred to direct the foam stream to the upper end of the open drains, sumps or pits so that the foam may flow with the product. In such cases, it is often desirable to detach the nozzle from the deluge set or hose line so as to eliminate velocity.

8. *Asbestos tube.* A comparatively recent development in the art of foam fire fighting is the "Moeller tube." This device consists of a loosely woven asbestos tube which is attached either to fixed foam delivery chambers, portable foam towers, or the ends of deluge sets. The buoyancy of the foam will float this tube out on to the oil surface and deliver foam directly on the surface, eliminating agitation to the product, protecting the foam from updraft, etc., and in short, increasing the efficiency of the foam equipment considerably. This device is particularly valuable where large areas are involved or extremely volatile products encountered.

Fuel + Oxygen + Ignition Temperature=Fire



Sulfuric acid alkylation unit in the new plant of The Texas Company, Wilmington (Los Angeles Works), California

Texaco Adds 100-Octane Capacity At Los Angeles Works

FACILITIES for making 100-octane aviation gasoline in the plant of The Texas Company, Wilmington, California, were completed last month. Principal additions, which cost $21,000,000, are a crude-distillation unit, a fluid-catalytic unit, more fractionating capacity, and additional steam plant and water-cooling equipment.

The plant, known as the Los Angeles works, now can process 42,500 barrels of crude oil daily. From this it will produce more than 10,000 barrels of 100-octane fuel and an additional 2000 barrels of other military gasolines.

The new facilities were briefly described by the engineering department of The Texas Company when the new units went on stream, as follows:

Crude Stills

A new crude-still unit capable of running 12,500 barrels per day of 36-42 API gravity crude oil has been completed and is in operaiton. This unit consists of a pipe still furnace, fractionating tower, two stripping towers, together with the required pumps, lines, condensers, coolers, and other necessary auxiliary equipment for efficient operation. This unit will produce straight-run naphtha of any desired endponit, kerosine distillate, gasoil and a straight-run fuel residuum of 250 to 300 Saybolt Furol viscosity at 122° F.

This unit was so designed as to permit the refractionation of 7500 barrels per day of 375° F. straight-run naphtha produced on other crude still units at this plant, which operating procedure is novel and unusual, and which eliminates the necessity of a separate rerun unit for such purposes.

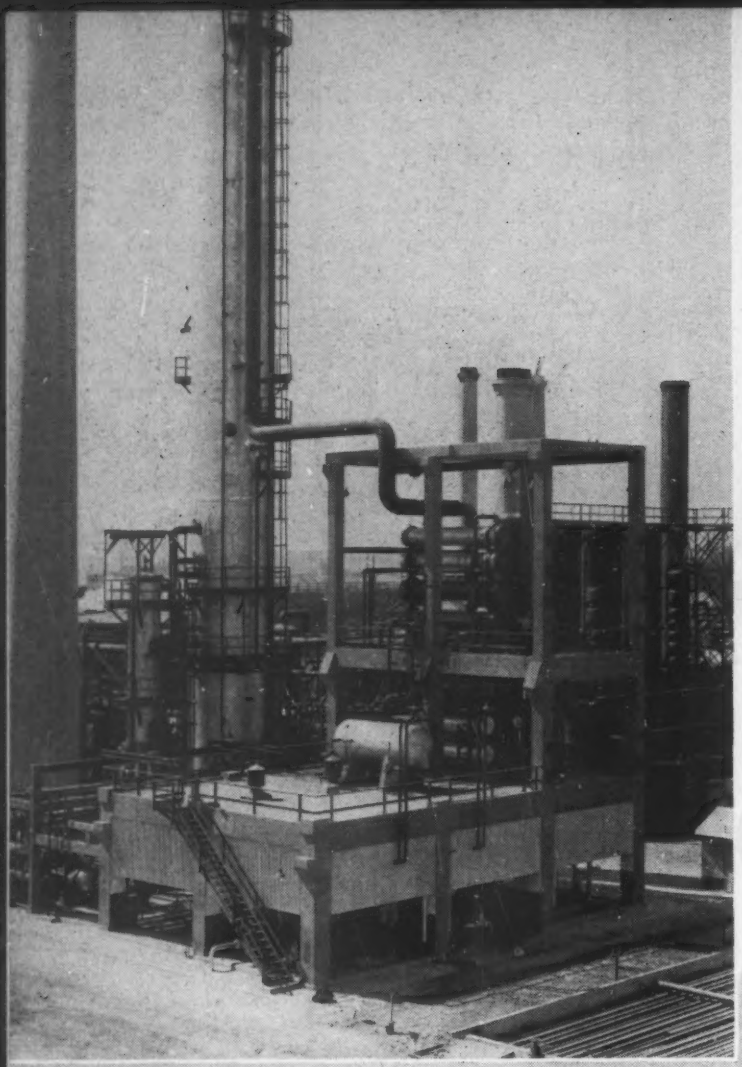
Superfractionator

Superfractionator equipment was designed for processing 15,000 barrels per day of combined charge made up of depropanized natural gasoline, straight-run naphtha, vapor-recovery compressor gasoline and any pentane and lighter fractions from the No. 1 and No. 2 alkylation plant operations.

Six fractionating towers operate in this unit. The first column debutanizes the charge, fractionating off an iso-butane-n-butane fraction which goes to No. 2 alkylation plant for further processing; the second column depentanizes the debutanized stock; the third column splits the pentanes fraction into iso-pentane and normal pentane; the fourth, fifth and sixth columns produce as overhead products respectively a hexanes-iso-heptane cut, an n-heptane cut, and an iso-octane cut. The bottoms from the sixth tower are n-octane and heavier. The respective products are segregated for use to the best advantage in military aviation products, motor gasoline, and for further processing.

The dimensions of the columns are as follows: debutanizer, 6 feet-6 inches x 67 feet-8 inches, depentanizer 6 x 129 feet, deiso-pentanizer 8 x 162 feet, deiso-heptanizer 9 feet x 160 feet-6 inches, deheptanizer 7 x 163 feet, and deiso-octanizer 6 x 145 feet.

A new unit for the production of certain desired hydrocarbon fractions by the use of catalytic cracking was installed and is now starting operation. This



unit consists of a reactor, a regenerator, a precipitator, a bubble tower and fractionating equipment. This operation consists of contacting the charge with a powdered synthetic catalyst at temperatures between 950 and 1050° F., dependent upon the final products desired.

After the reaction between the catalyst and the oil charge, which by the way, is a distillate having a distillation range between 375 to 900° F., the vapors are cooled and go to the fractionating side of this unit where the catalytic distillate is depropanized and split into butylenes, pentylenes, C6—185° F. and fractions boiling between 185 to 210° F.; 210 to 300° F.; 300 to 400° F. as well as light and heavy cycle gas oils. These products are delivered to storage for further processing at the alkylation units, treating plants, and other operating departments.

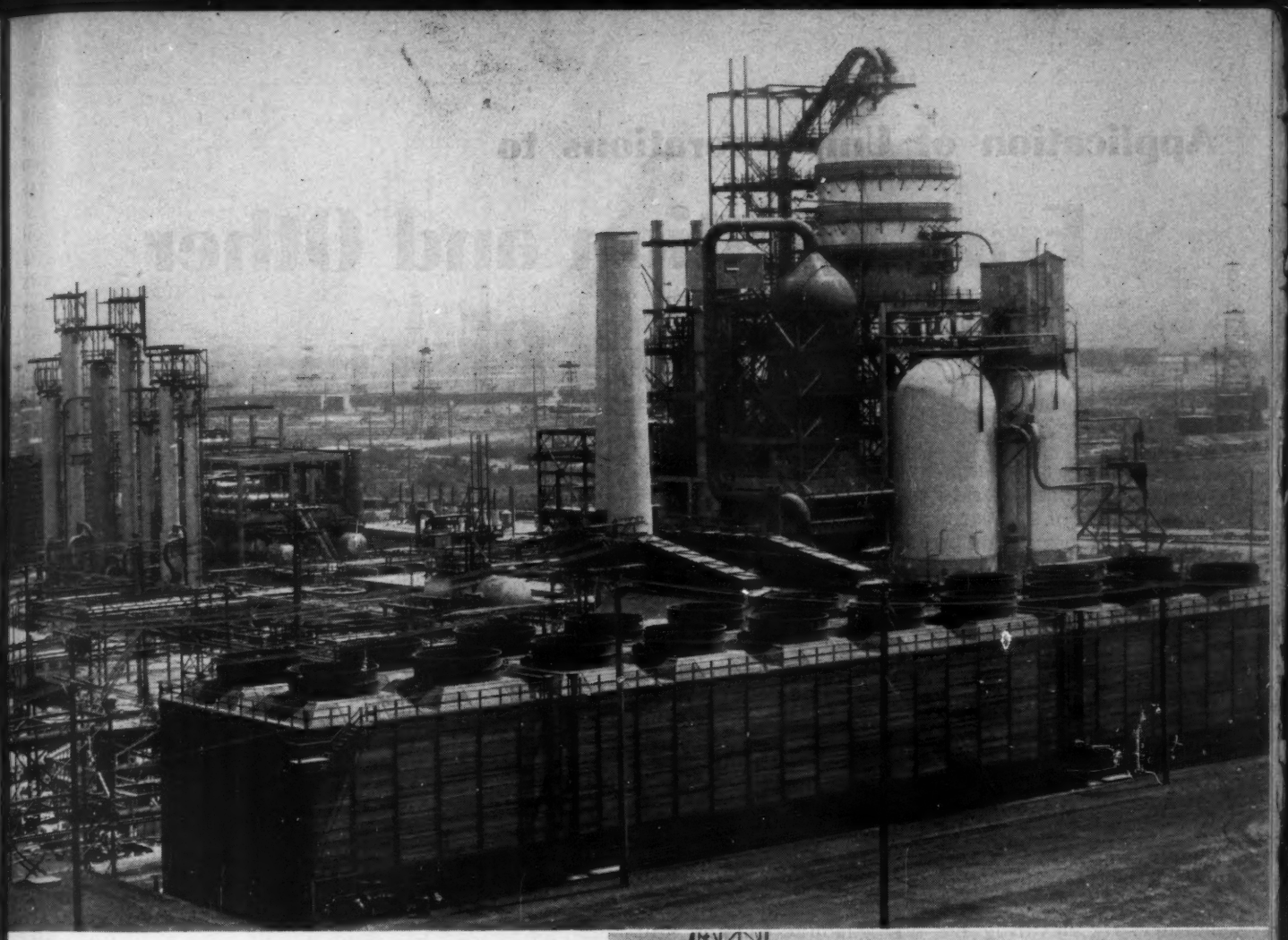
This fluid catalytic cracking operation is unique in its mechanical control apparatus. More than 500 control instruments are in use on this unit, the failure of any one of which could seriously affect the efficient operation of this equipment.

The new feed preparation unit is used to improve the quality of both the thermal and catalytic olefins prior to their use on the alkylation units.

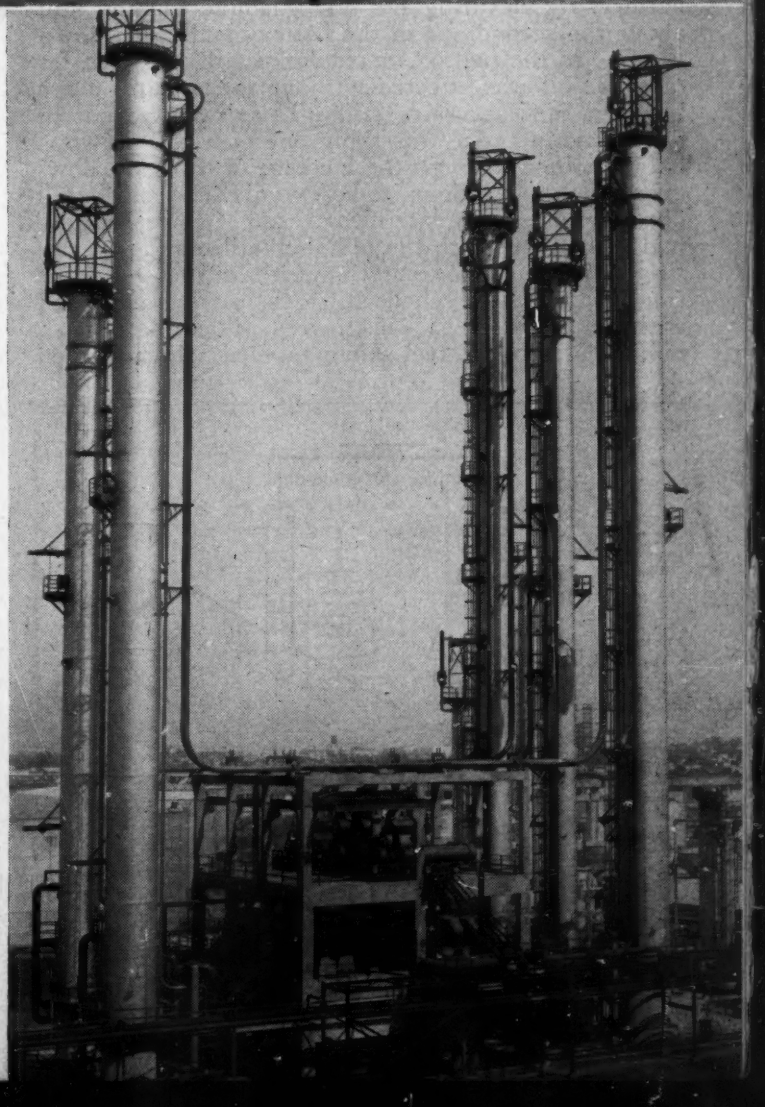
A caustic wash is given the thermal butylenes for

Crude oil distillation and naphtha rerun unit at The Texas Company's Los Angeles Works.

Fluid catalytic cracking unit. At left in the foreground is the circular furnace type heater.



Induced-draft cooling tower in the foreground handles 30,000 gallons of water per minute.



This superfractionator is designed to produce six closely fractionated hydrocarbons.

mercaptan removal and a weak-acid treatment is given the thermal pentylene for removal of diolefins. A rerun operation is provided for the removal of any polymers which might be produced in the week-acid treating operations.

The catalytic butylenes are given no treatment of any kind. The catalytic pentylenes are caustic washed for mercaptan removal and also are given a weak-acid treat for diolefin removal with a resultant rerun for removal of polymers.

The following columns are included in the feed preparation unit: a 3-foot and 5 x 88-foot-6-inch primary depropanizer, 2 x 38-foot thermal olefin and 3-foot-6-inch x 42-foot catalytic pentylene caustic washers, a 3 x 26-foot caustic regenerator, a 3- and 4- x 76-foot primary debutanizer, and a 3 x 41-foot-6-inch rerun tower.

The new alkylation plant facilities consist of the necessary fractionating towers, acid contactors, neutralizing equipment and rerun stills to permit the combination of olefinic butylenes (C_4) and pentylenes (C_5) with iso-butane to produce alkylate which is the base for the manufacture of 100-octane aviation gasoline. During this process depropanization, deisobutanization, and debutanization of either the charge or the resultant products take place as well as a final rerun operation to eliminate the polymers produced in the alkylation process.

Application of Unit Operations to

Fractionation and Other Vaporization Processes

PART 9

Distillation and Fractionation

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ONE of the most important unit operations which the refiner and natural-gasoline manufacturer performs is that of separating mixtures of hydrocarbons having different vapor pressures into narrow boiling products.

Early in the life of the petroleum industry this operation was called distillation. It consisted of the simple batch process of charging a shell still (Figure 1) about two thirds full of crude oil and then gradually increasing the temperature of the contents at atmospheric pressure until the lighter fractions such as gasoline, kerosine and gasoil were vaporized and condensed in an overhead coil. As larger demands were made on refineries for increased output, efforts were directed toward development of continuous operations, and as a result the crude-oil charge was flowed at a steady rate through several shell stills in series (Figure 2), the temperature becoming higher as the stream progressed through the battery. By elevating the first gasoline topping still above the second one in the battery and so on down the line to the fuel oil or residuum still, the transfer of crude oil was effected without the use of pumps between the successive stills. This improvement in distillation practice was a big one over the previous batch method through the increase of capacity, however, such operations today would be considered obsolete and too wasteful of heat. Much rerunning had to be done with the old shell-still operation until the industry became cognizant of the need for fractionation. The shell stills then were equipped with uninsulated packed towers (filled with such materials as rock, steel shavings, etc.) which formed some reflux through the loss of heat to the atmosphere. Rapidly changing weather conditions would cause variable reflux rates and no small amount of difficulty in controlling the desired product.

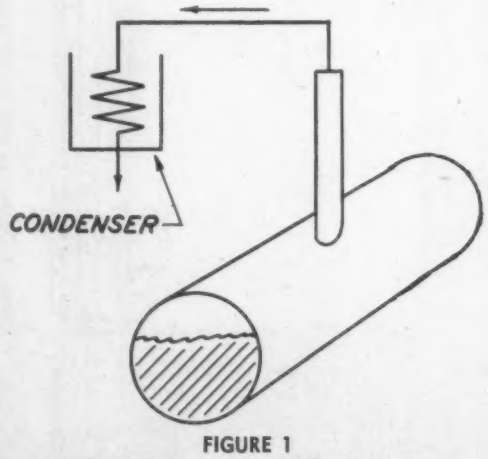

FIGURE 1
Batch still first used for crude-oil distillation

Today the pipe still (Figure 3) has taken the place of the shell with a few exceptions such as when a batch of a volatile solvent or diluent may have to be recovered from a non-volatile residue or extract. The pipe still offers advantages over the shell still:

1. Increase in heat transfer efficiencies.
2. Prevention of localized overheating and coking (frequent occurrence in shell-still bottoms).
3. Less danger of excessive loss of oil in case of fire.
4. Closer approach to flash vaporization in the pipe still.

Development of Fractionation

The packed tower which had been super-imposed upon the shell still, was transferred to the discharge of the pipe still. It was increased in height and instead of rock and steel shavings, further improvement in fractionation was accomplished through the use of various types of Raschig rings and spiral helices which provided greater surface areas for the contact of liquid and vapor. The industry was becoming aware of the fact, in the early twenties, that other industries had advanced the art of fractionation to a much higher degree than the oil companies.

About this time the natural-gasoline industry was forced to stabilize its raw production in order to meet certain motor-fuel requirements, and to reduce shipping losses. The price these manufacturers had to pay by weathering the raw production to specification, was exorbitant, so the natural-gasoline engineer welcomed the bubble-plate fractionating column as a means of reducing losses.

Bubble-Plate Fractionator Design

1. Heat Input and Output.

A fractionator is essentially a counter-current adiabatic heat-exchanger. (See Figure 4.) Heat enters the column at two points, as a rule, namely at the feed plate and in the reboiler at the base of the

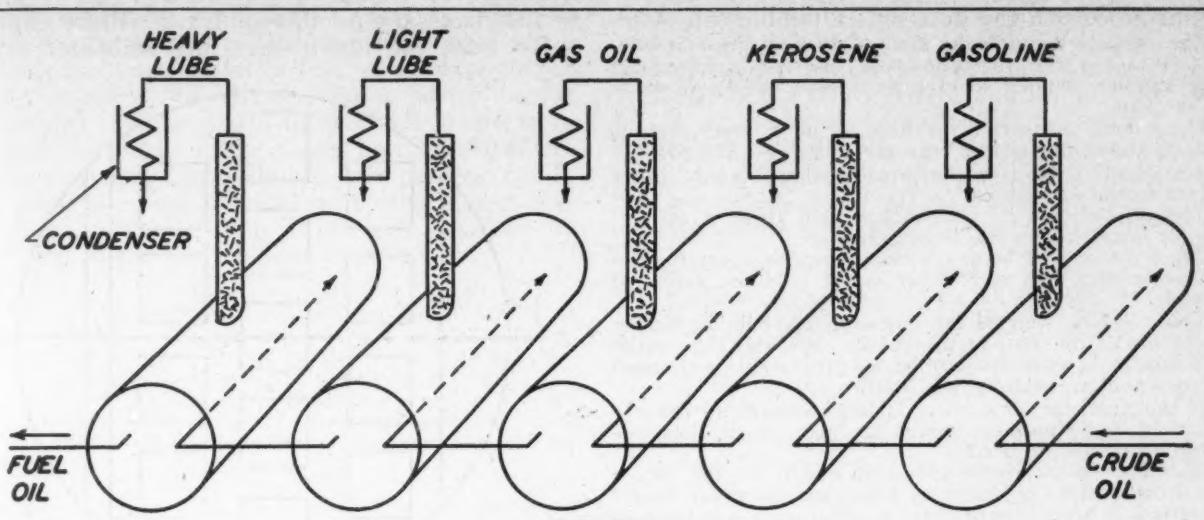

FIGURE 2
Continuous shell-still battery in common use 1910 to 1925

tower. Since a very small fraction of the heat is lost by radiation through the insulation or by the removal of liquid products from the column, the major portion of the heat goes overhead in the vapor stream. This latent heat is absorbed by cooling water through the condensation of this vapor into liquid. A part of this liquid is in turn refluxed or pumped back into the top of the column to provide the liquid-vapor contact which is essential for the attainment of fractionation. Were no liquid condensed from the overhead vapor, the small amount of internal reflux which would form in the column would be equivalent only to the heat lost by conduction through the insulated walls. Some of the early designers called for no insulation of the tower so that more reflux might be formed as the result of atmospheric cooling; but, as mentioned before in the case of the rock-packed tower, the close control of such a column under adverse or changing weather conditions was out of the question.

2. The Bubble-Plate and Downspout.

The efficiency of a fractionating column depends largely upon the intimacy of contact between the descending liquid reflux and the ascending stream of vapor. The packed column provided the necessary degree of efficiency so long as the packing remained intact. There was too often a tendency for this packing to shift and thereby permit the vapor to pass upward along one side of the tower without coming into well-distributed contact with the descending liquid.

The bubble plate can be depended upon to give uniformly good results from year to year unless corrosion causes appreciable reduction in the cross sectional area of the slots in the caps. The perforated plate (no bubble caps) has proven to be quite efficient for mixed liquid and gas loads. Below this specific load, the intimacy of contact is not adequate while excessive gas or reflux loads will prevent the downflow of liquid and the resultant priming or flooding of the tower unless the plate is provided with a downspout. The perforated or sieve plate may compete with the bubble-cap tray in the not too distant future.

A typical bubble-cap plate is shown in Figure 5, with the vertical and horizontal projections. The word "typical" might be contested, however, as the number of cap styles is legion, varying in shape such as square, round or oblong, not to mention the slots which may be rectangular, triangular or tangential. Several cardinal points are to be observed in general,

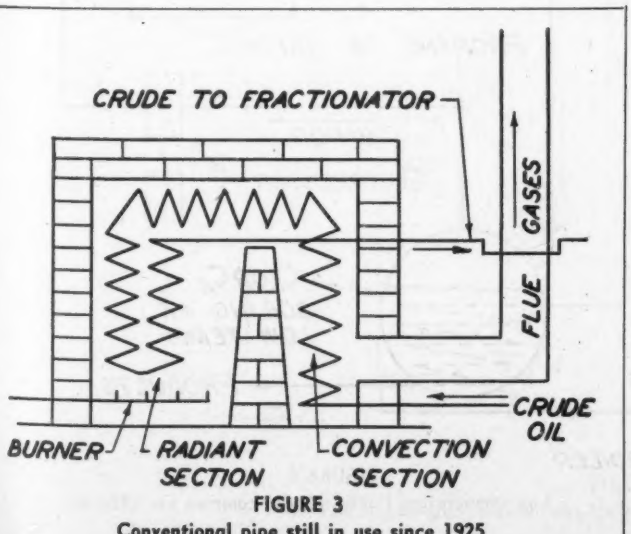

FIGURE 3
Conventional pipe still in use since 1925

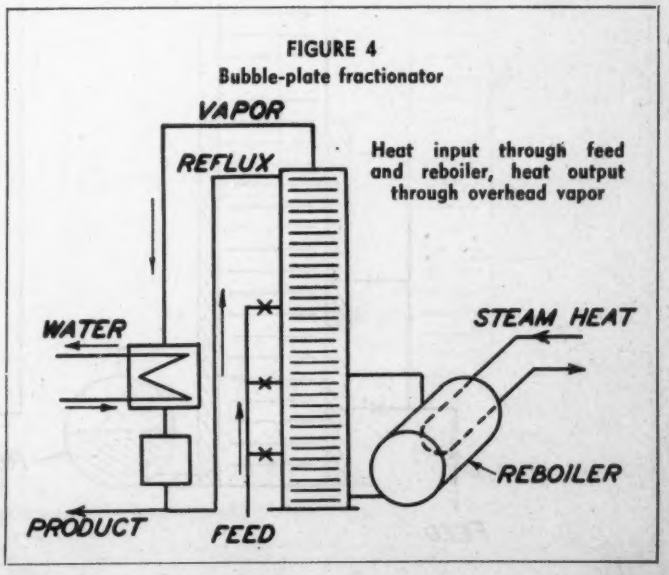

FIGURE 4
Bubble-plate fractionator

in connection with the design of a bubble cap plate.

1. The velocity through the slots of the cap must be adequate to assure the formation of countless numbers of minute bubbles, but not so high as to blow the liquid away from the cap.
2. The overall pressure drop through the chimney, bubble cap slots, and liquid on the tray must be less than the hydrostatic head of fluid in the downspout, otherwise vapor will flow up the downspout.[3,6]
3. The caps should be so arranged that there is no tendency for liquid to channel across the plate.
4. The caps should be a sufficient distance apart to prevent interference with each other in the bubbling action of the vapor.
5. The overflow weir of the downspout should be higher than the top of the slots in the bubble caps, this differential height depending upon the permissible pressure drop through the liquid and froth above the plate.
6. If the diameter of a tower is large enough to cause a pronounced liquid gradient across the plate, more than one downspout should be used.
7. The downspout size is governed largely by the nature of the froth and its tendency to disengage its vapor load.[4,7] The trend has been toward the use of larger tapered downspouts by blocking off a segment of the tower, the spout being smaller at its base in order to provide for more bubble caps on each plate.
8. The distance between plates depends mostly upon the mass velocity of the vapor flowing upward through the tower.[3,5,6]

In 1923, when the natural-gasoline industry first took up the practice of fractionation by removing the propane from the raw gasoline, relatively low temperatures and pressures were used. Satisfactory results were obtained but the cost of refrigerating the overhead reflux proved to be excessive. The refrigeration system usually consisted of a butane or propane cycle (Figure 6) in which a number of compressors were required for the transfer of heat from the overhead condenser to the water-cooling tower. The low-temperature tower did have the advantage in that fewer bubble plates were needed in order to effect a certain amount of fractionation than a high-pressure high-temperature column would require. In a later paper, the theoretical reasons for this reduction in the necessary number of trays will be explained.

By 1930, the low-temperature stabilizer columns

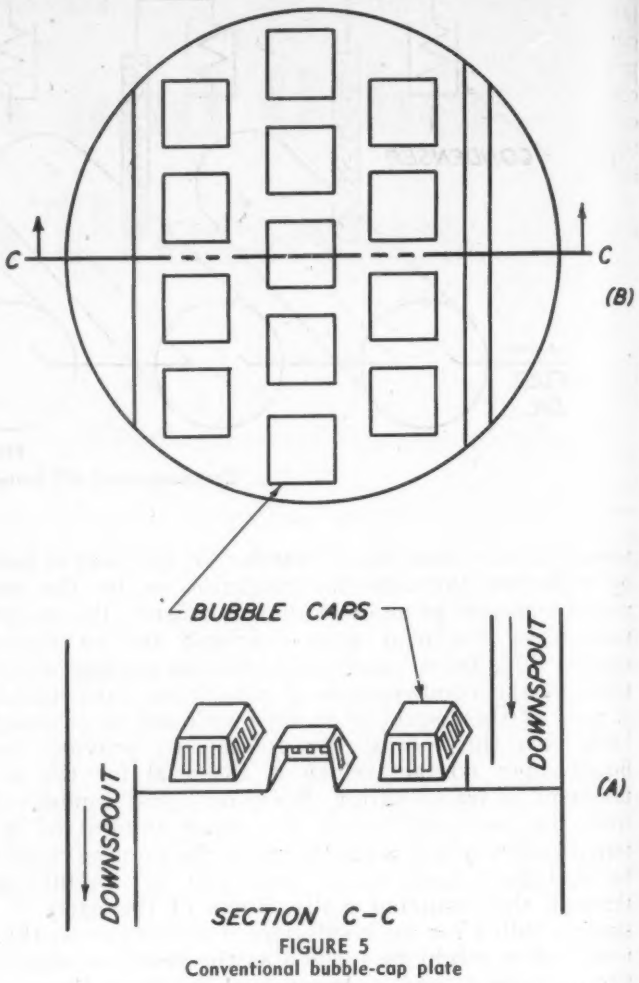

FIGURE 5
Conventional bubble-cap plate

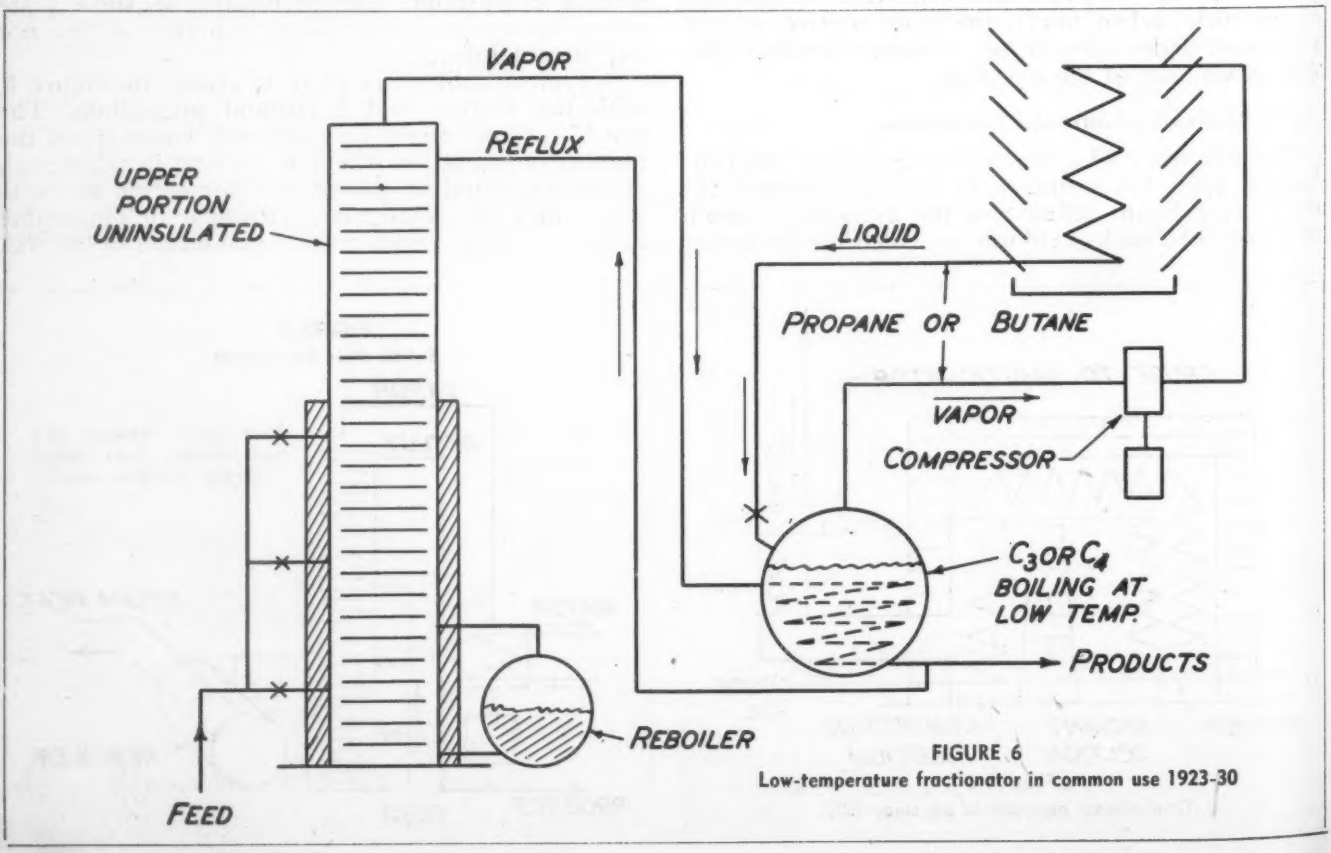

FIGURE 6
Low-temperature fractionator in common use 1923-30

had been practically supplanted by towers operating under higher temperatures through the use of water as a condensation medium instead of propane or butane. By making this change, the capacity of the columns was increased due to the higher operating pressures. For example the throughput of the tower could be raised by approximately 40 percent by increasing the pressure from 50 up to 100 pounds per square inch, absolute. This value was obtained by substitution in the entrainment equation.[6]

$$W = C\,[d_2(d_1 - d_2)]^{1/2}$$

where W = mass velocity of vapor in lbs./hr./sq.ft. of tower cross section
C = a constant, dependent upon the tray spacing, physical properties of the fluids, etc.
d_2 = density of vapor in consistent units.
d_1 = density of liquid, in consistent units.

Except for extremely high pressures, the equation can be simplified to:

$$W = C\,(d_2 d_1)^{1/2}$$

The big saving through high-temperature fractionation came through the use of water as a cooling medium to condense the overhead product.

The exacting specifications which the natural-gasoline industry must meet in the manufacture of close-cut fractions has eliminated the use of the side-stripper. As a general rule, it requires at least (N — 1) towers to make (N) products. For example it would take two towers to separate a three-component mixture such as:

	Mol%
Propane	30
N Butane	30
N Pentane	40

into its respective components. This result can be accomplished by two different procedures as indicated by Figure 7. The second one of these two methods (7b) is the more economical to operate as the heat requirements as well as the vapor load would be considerably greater for column 1 (7a) with the production of both propane and normal butane as overhead products than it would be for column 1 (7b). Furthermore, the overhead reflux from column 1 (7a) would have to be preheated before charging into column 2 (7a) whereas the hot bottoms from column 1 (7b) could be flowed directly into column 2 (7b) without preheating.

Another distinct advantage of installation (7b) over (7a) is the reduction in pumping costs, since a booster pump would be required to transfer the overhead liquid reflux from column 1 (7a) to column 2 (7a). If the overhead vapor from column 1 (7a) is condensed at 100° F. the pressure on the tower would be substantially the same as the vapor pressure or bubble point of the reflux at 100° F. This vapor pressure would be calculated as follows:

	Mol Fraction		Vapor Pressure		Partial Pressure
Propane	.50	×	188	=	94.0
N Butane	.50	×	53	=	26.5
Total pressure, lb./sq.in.absolute					120.5

Or 120.5 — 14.7 = 105.8 lbs. per sq. inch, gauge, pressure.

The pressures on column 2 (7a) and column 1 (7b) would be the same, a pressure slightly above the vapor pressure of pure propane at 100° F. or 188 pounds per square inch, absolute.

Column 2 (7b) would have a pressure a little higher than 53 pounds per square inch absolute, the vapor pressure of normal butane at 100° F. This advantage in reduction of pumping equipment costs in the case of 7b is small, however, in comparison with the saving in fractionator and steam cost as column 1 (7a) will necessarily have to be designed to handle twice the vapor, heating and overhead condensing load that column 1 (7b) would require.

Better control of the reflux ratio can be had by placing the condensers for the overhead vapor near the ground level. Some of the earlier columns were equipped with the condenser placed on top of the tower, having a weir adjustment to control the reflux rate back into the tower by gravitation. Operators seldom climbed to the top of such columns to see how well the reflux flow was under control.

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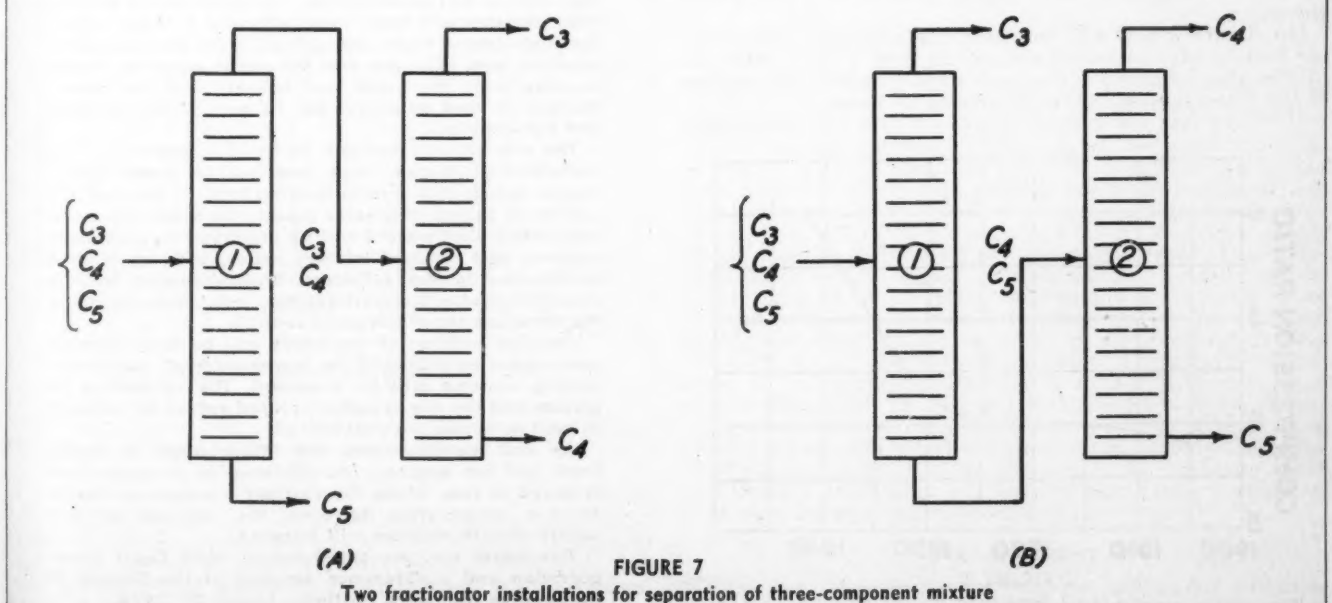


FIGURE 7
Two fractionator installations for separation of three-component mixture

Possibilities of Gasoline-Engine Development

FOREST S. BASTER

Vice President in Charge of Engineering, The White Motor Company

IN THE past few months many prophets have arisen to forecast the future of this or that, so I will be in very good company if I join them and attempt to prophesy the things which we may expect in the future gasoline engine. In attempting to forecast, one must first recognize that the gasoline engine is a heat engine, and it is only through increased thermal and mechanical efficiency that we may expect to extract more actual foot-pounds of work from a dollar's worth of fuel.

Perhaps it would be best to review a bit of the history of commercial truck and bus engines with regard to compression ratios, average revolutions per minute at peak horsepower, pounds per brake horsepower and average displacement. On Figure 1 we can see that the compression ratio from approximately 1905 to 1925 stayed constant at 3½ or 4:1. At that time a comparatively rapid increase in compression ratio started to take place and the average list in the trade journals as of 1940 is approximately 6:1.

On Figure 2 is shown that for the same period, that is up to 1925, the average engine in a commercial vehicle had 4 cylinders; and in the next 10 years there was a rather rapid swing to 6 cylinders.

On Figure 3 we show that over this same period the engine weight in pounds-per-brake-horsepower output has gradually decreased from approximately 35 pounds in 1905 to a little less than 10 pounds in 1940.

Figure 4 shows that the average road speed at which the commercial vehicles has been governed has increased in a rather smooth curve from approximately 9 miles per hour to today's 50 plus miles per hour.

On Figure 5 the displacement of the average commercial engine has in the meantime decreased from about 380 cubic inches to approximately 330 cubic inches; and despite this decrease in displacement, the horsepower outputs shown on Figure 6 have increased about six times to a point where the average engine is very closely approaching 100 horsepower.

On Figure 7 you will note that the governed revolutions per minute have increased meanwhile from 1000 to 3000. All of the above figures and charts were obtained by analysis of the trade journals over this period of years.

If we project these same curves on into the future with

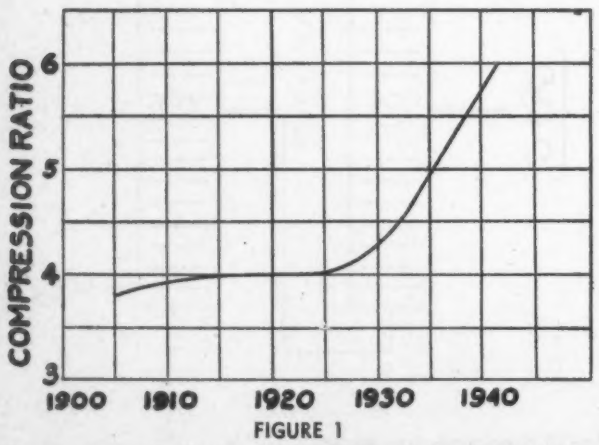


FIGURE 1

Compression ratio changes, 1905-1925. Trend of engine variables in 3- to 4-ton trucks (averaged).

THAT truck and bus engines of the future will be redesigned to take advantage of the many wartime developments and improvements is brought out in this paper which was delivered before the West Coast Transportation and Maintenance Meeting of the Society of Automotive Engineers at Portland. One of the greatest influences for gasoline engine improvement will be the greatly improved fuels available. High-octane gasolines perfected during the war are bound to precipitate changes in engine design so that the new opportunities can be realized.

Widespread development of processes and materials during the war is going to open the way for many advancements. In the material field alone, the possibilities are almost unlimited. Not only are new alloys available to work with today, but the expansion of production facilities has put aluminum within reach of all. The lighter, stronger metals will exert a considerable influence in postwar design.

The degree of progress during the war has been much greater than during any like peacetime period because of the unusual stimulation. Thus the advancement in gasoline engines during the next few years should be greater than for any normal period.

The era up to 1925 was one of four-cylinder engines and low compression ratios, whereas the period from 1925 to 1940 was one of six-cylinder engines and increasing compression ratios. The trend was in the direction of more power and greater speed.

The engine of the future will have greater power with less weight, and the compression ratio will be increased from the present average 6:1 in line with high-octane-fuel opportunities. Developments of the aircraft industry will have their influence in many ways. The high-octane fuels, themselves, were developed for aviation, and after the war 90-octane gasoline should be obtainable for trucks and busses. Even the supercharger as used on planes has its possibilities on truck and bus engines.

The aircraft influence will be found in better bearing materials, in better rings and various other parts. Higher speeds and greater bearing loads in general will call for oil pumps of greater capacity to insure adequate lubrication. Carburetors will be improved to give more accurate and constant mixture ratios, with more even distribution in the cylinders. Direct-injection has its possibilities also, but much remains to be done, including the development of adequate controls.

Gasoline engines of the future will be more durable and rugged to withstand the increased heat, and better cooling systems will be provided. The oil-cooling of pistons and the use of sodium-cooled valves for exhaust as well as intake are possibilities.

As such developments are incorporated in future truck and bus engines, the efficiency of transportation is bound to rise. While the cost per horsepower should show a comparative decrease, the payload carrying ability of such vehicles will increase.

This paper was presented before West Coast transportation and maintenance meeting of the Society of Automotive Engineers, Portland, August 24, 1944.

approximately the same rate of change, we will arrive at horsepower, speeds and weight per horsepower which, at first glance, appears to be a rather fair improvement. We believe, however, that we cannot just project them at the same rate of increase; during the past few years under wartime stress we have made progress at a considerably faster pace than in normal peace times.

Our consideration of the engine of the future must be based on fuels available as well as materials which we will have available at this time. There have been remarkable improvements in gasoline and oil technology, as we all know, forced upon us by requirements for higher and higher outputs and BMEP for combat aircraft. For this engine of the future we believe that the non-premium gasoline will be at least 90-octane and the lighter alloys (aluminum and magnesium) will be priced competitively with cast iron. This 90-octane fuel will be far superior in road performance to the 87-90-octane fuel which was available before the war as aircraft gasoline. It has been found that the octane rating arrived at by ASTM or so-called motor method, or by the CFR—Research Method, does not give a true indication of the performance of gasolines on the road. For some time we believed that a combination of these two methods or the sensitivity as it was called, gave comparatively good correlation with road performance; but since that time the CFR road testing has developed the fact that some gasolines, even though rated the same by each of the two methods, gave quite different performance upon the road.

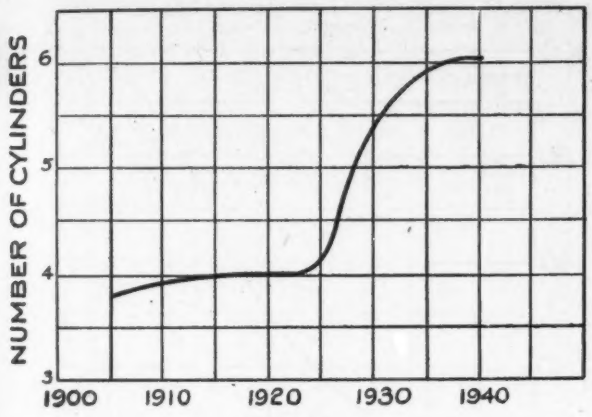


FIGURE 2

Average number of cylinders, 1905-1925.

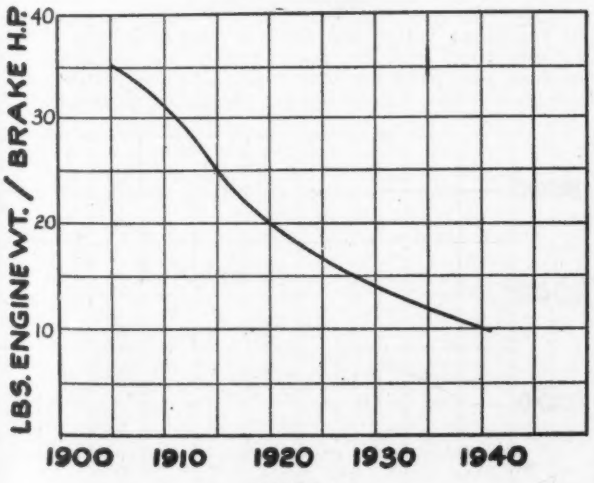


FIGURE 3

Engine weight per brake horsepower, 1905-1940.

Made To Order

During the past few years oil technologists have succeeded in building gasolines practically to order. Figure 8 shows the curves of three different gasolines all with the same ASTM octane number and two of them with the same Research octane number. The normally aspirated engine has an octane requirement shown by the dot-and-dash line decreasing as engine speed is increased. As can be seen from the chart, gasoline "B" with an 80 rating by ASTM and Research will be of too low a quality for speeds below 1800. Gasoline "A" does somewhat approach the typical slope, whereas, gasoline "C" with the same rating by ASTM and Research methods shows that it would be possible to increase the compression ratio of the engine were the manufacturer certain that no other gasoline other than those similar to "C" were ever going to be used in that engine.

Now let us look into the crystal ball and see what the future holds for us. Engines will, in all probability, be no smaller physicaly than those now in use but will have considerably higher output. In the not too distant future it is easily conceivable that we shall have engines developing 165 BMEP unsupercharged and 200 BMEP supercharged with .55 to .6 horsepower per cubic inch in the normally aspirated engine, and even more in the supercharged version.

Perhaps this seems to be shooting for a star, but you may remember that a paper given in New York in November, 1938, forecast 125 BMEP and at the moment that seemed audacious, but within a year that goal had been surpassed. There is today an engine which is developing over 140 BMEP with 80-octane fuel, so we are well along the way and this forecast of 165 BMEP may also prove to be too conservative.

The cost of these engines will be lower when measured in dollars per horsepower even though the dollars per cubic inch of displacement may rise due to better quality of materials which in turn contribute to longer life and lowered maintenance.

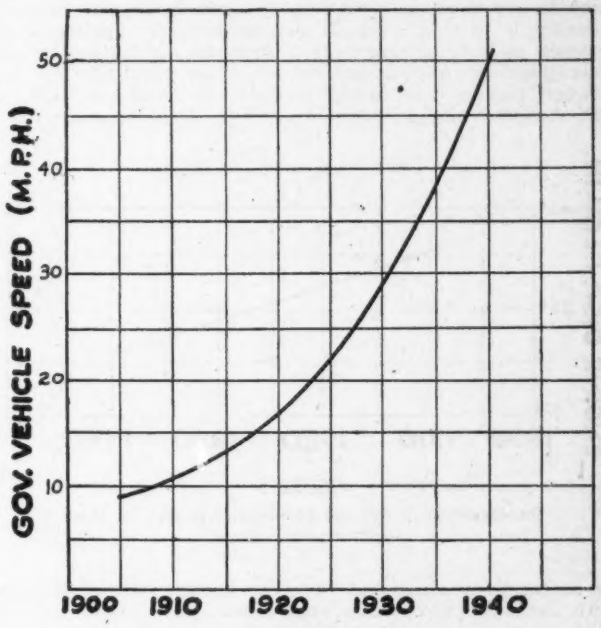


FIGURE 4

Average road speed, 1905-1940.

These higher outputs will be needed, for after the close of hostilities, this nation undoubtedly will have an era of road building which will produce main intersectional and transcontinental roads which will permit high speeds, and this in turn may lead to legislation as to minimum speeds which must be maintained even on the upgrade. This minimum speed will be such that more and more power will be needed, and we manufacturrs will supply it. In order to do this, we will have to take full advantage of the fuel and completely redesign our engines to most advantageously use fuels we believe will be available. Fuels alone should allow 10 to 15 percent increase in output with very little change other than that we put in high-compression pistons or shave a little off the head. There are quite a number of ways in which additional performance can be obtained, some of which may appear at the moment to be "gadgetry," but with further intelligent engineering development some of these may become quite the acceptable thing.

Electronic Timing

With the increase in compression ratios, for instance, spark timing will perhaps become much more exact than that given by our present distributors with their rather

wide tolerances as built in today's production. Distributor points have been a source of a good many headaches for, as the fiber block wears, spark timing on the engine changes and the need for frequent maintenance has been a nuisance. There are at last two and possibly three different ways known at the present time by which these points could be eliminated. These systems would require a few electronic tubes but that can no longer be considered very much of a hazard for in so many of the aircraft wrecks where the plane has been a complete washout, the one piece of equipment that most frequently can be salvaged is the radio and its tubes.

New ignition systems are being developed which may eliminate the present high-tension secondary leads with their accompanying tendency to leak, have corona breakdown and sometimes even cross fire. These new systems use low-tension distribution and step up the voltage at the spark plug. With higher pressures at full loads and probably leaner mixtures at full and part load, both new spark plug design and higher impressed voltage on the plug points may be required in order to fire the mixture.

Spark plugs, too, are being developed rather rapidly and progress with electrodes made of platinum and tungsten, some using thorium, are now in production. These metals and alloys are used to increase the emissivity, or in other words, to more easily surround the points with electrons so that the spark might jump across the gap with a lesser impressed voltage. The mechanical design of the plug is also being improved and plugs will now operate for very much longer periods even with the heavily leaded fuels. As an example of this, a small and what might apparently be assumed to be a comparatively unimportant change in electrode positioning and spacing gave an extension of time between servicing of approximately ten times or 1000 percent. Another change permits control of the temperature of

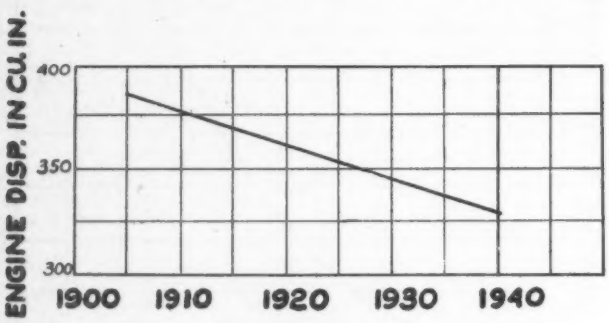


FIGURE 5

Displacement of average commercial engine for same load-carrying vehicle.

the center wire which has been the hottest part of the plug. With these improvements and others now under development, we may be fairly confident that the spark plug manufacturers will keep pace with anything that the commercial vehicle will require.

Bearing materials have been improved tremendously in the past few years under the stress of aircraft developmnt. In today's engines copper-lead bearings are widely used both for main and connecting-rod big ends. In the latter use, the loading is in the vicinity of 1200 pounds per square inch. These bearings carry manufacturers' rating of about 3000 pounds per square inch. Bearing manufacturers are aiming and seem to be fairly confident of obtaining bearings that will handle loads of more than 2000 pounds per square inch, with the same relative margin between actual and manufacturers' ratings. This manufacturers' rating is made on standard bearing test machines which are used with slight variations by each of the bearing makers. Wear is measured after a given time with the rated load and if the wear falls below a previously established figure the bearing is approved for this rating. Aluminum bearings seem to be potentially capable of rapid development. Silver bearings offer quite a bit in load-carrying capacity and it is stated that they will permit extended life of the crankshaft. However, at the present time the silver bearing costs from two to three times that of the best present day copper-lead bearing. New methods of manufacture including the plating process may considerably reduce the final cost of a bearing of this type and if it can be used for greater mileages will certainly be acceptable. In connection with the plated bearing, the art and knowledge has progressed rapidly during the war and special platings of .0005-inch on a bearing can apparently make all the difference between one which will run 100,000 miles or more and failure in a few thousand miles, indicating that texture of the finish as well as compatability of the metals can be a big factor in increasing bearing capacity and life. To date, lead and indium have been the metals most often used in the plating of commercial bearings, but considerable research has been going on with the plating of other metals and much is expected from this research. With engine speeds increasing it seems imperative that we keep our piston weights as low as commercially practicable, and this seems to point rather definitely to the continued use of

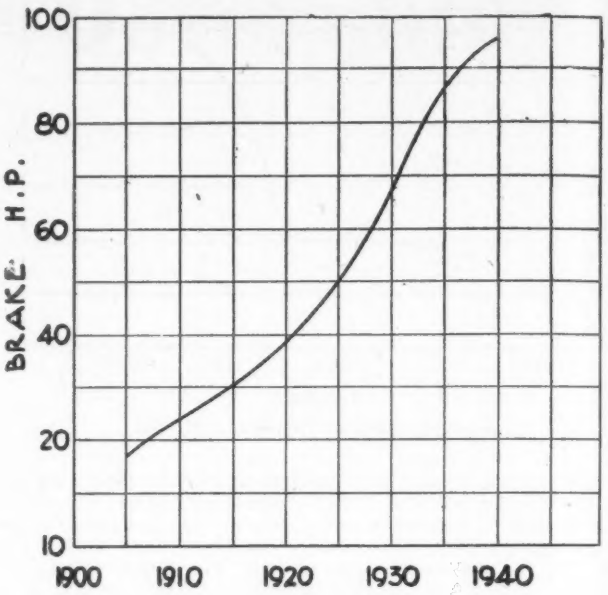


FIGURE 6

Yearly increase in power, 1905-1940.

aluminum. We know that ring groove wear is sometimes rather rapid when air cleaners are not serviced often but that is a completely separate problem. Aluminum pistons may be produced by new methods or combinations of methods now in use so that the future piston may come from a machine which will produce a combined forged and extruded piston. These may be both stronger and cheaper to manufacture, even cheaper than the permanent-mold casting.

From Metallurgy

The technique which has been developed in manufacture of aircraft rings will be continued in the production of commercial and passenger-car rings. Chrome plating of the compression rings has shown a decided improvement in

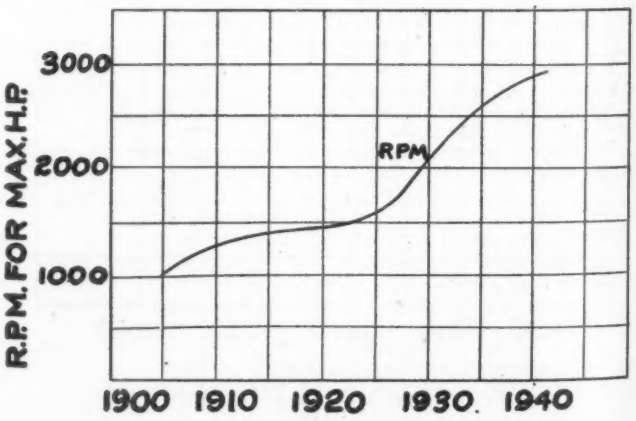


FIGURE 7

Governed RPM changes.

wear characteristics. It has been found that both the wear on the ring and the wear at the top of the cylinder barrel has been decreased remarkably, particularly when some dirt is present. Ring tension and radiol distribution of ring pressure studies have been carried on and better sealing and better oil control can be expected.

A number of today's commercial engines of comparatively

high output have been using the sodium cooled exhaust valve. While the cost of these valves seems today to be rather high, methods of manufacture are now being developed whereby the cost can be materially decreased without affecting life. Metallurgical advances in valve steels have progressed so that in engines of moderate output it may be possible to use more economical plain valves.

Valve seats are being developed which may take care of some small misalignment and eccentricity of the valve or a head which is slightly tipped out of the plane perpendicular to the valve stem. These seats have been tried in some very

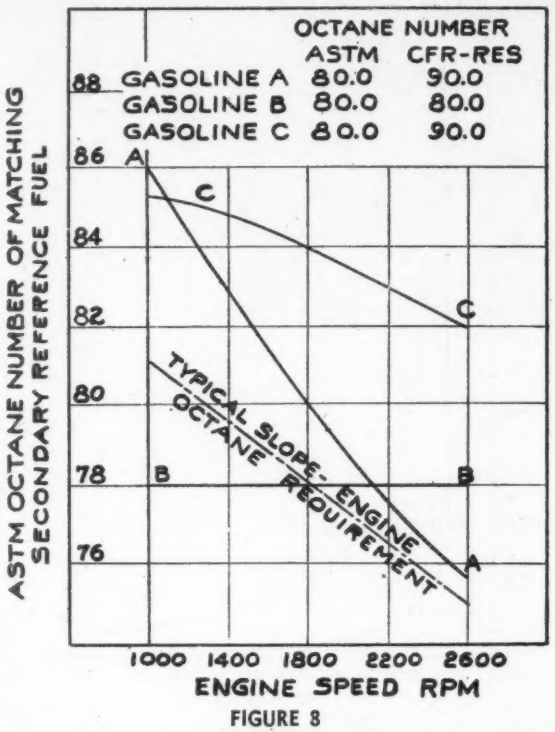


FIGURE 8

Variations in equivalent ASTM octane number with engine speed.

high output engines and have given a very good account of themselves.

Cooling and Cleaning

Oil-pump capacity will undoubtedly have to be increased for with higher bearing loading, as well as higher rubbing speeds, more heat will have to be carried away by the oil, and oil may even be used for piston cooling as it is in a number of today's diesel engines. With this increased load on the oil, filters will have to take a greater part in keeping the oil in good condition and will have to do so with little or no attention. The filter that will efficiently service a high-output engine will not be just a blown up version of today's filters, for space in the engine compartment is even now at a premium and will continue to be in the future so that filters along with all other accessories must improve their efficiency as the engines are being improved so that they will not end up by requiring twice as much space as the engines themselves. Oil coolers must also be considered, as they too will have a bigger job to do in taking care of the additional heat which higher specific output entails, and despite this higher specific output we should be able to use the better grades of oil available today.

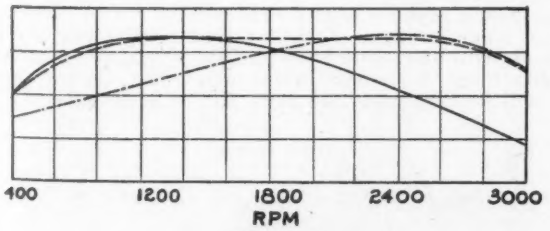


FIGURE 9

Effective valve timing.

Carburetors are, and will continue to be improved, in order to give more accurate and constant mixture ratios with better atomization in order to facilitate the more even distribution among the cylinders. One way in which this might be accomplished is by adapting some of the characteristics of today's aircraft engine injection carburetion. This same adaption might readily have an altitude control worked into the design at very little additional cost. This would undoubtedly be a great benefit to those truckers who are operating over mountainous country.

Injection carburetion naturally leads to the possibilities in injection. This may resolve itself into direct, manifold or port injection and appears to offer many possible advantages including that of a supposedly lower engine octane requirement with injection as contrasted to carburetion. We are all cognizant of the effect of heat in reducing volumetric efficiency, yet most engines have an exhaust-heated hot spot or a water-heated intake manifold. The distillation curve of the average gasoline automobile has a fairly high end point, and without the addition of this heat, distribution would be very difficult, for the wet ends of the fuel must be vaporized to get good distribution. With either direct or port injection the manifold would have to handle only air and, therefore, can be cold, thereby increasing volumetric efficiency and output over the entire speed range. Considerable work will, however, have to be done in the development of the necessary controls, but when these are worked out we undoubtedly will find other advantages which at the moment seem to be of little consequence. There has been quite a bit of discussion of the possibilities of water injection for commercial engines. This has been a natural result of the use of water injection for momentary bursts of power in combat aircraft engines. Considerable work was done on this problem at Wright Field about ten years ago and described by Ford L. Prescott at an ASME meeting in St. Louis in 1935. At that time a definite increase in thermal efficiency was noted. This has

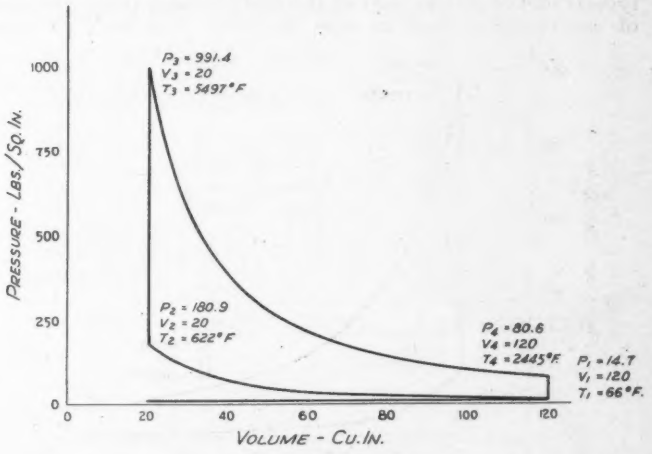


FIGURE 10

Ideal Otto Cycle

Compression ratio 6:1; efficiency 51.164 percent; net work, 1730.5 foot-pounds.

been corroborated by further testing since then. In commercial engines we do not at the moment know whether other effects may be present such as rapid rusting, increased wear or deterioration of the lubricants. There is much to be done on this problem and the possibilities look inviting. Injection of any type still is too expensive and will have to be materially simplified and reduced in cost to compete with a simple carburetor.

There are a number of design factors, each of which will lend its little bit to the final increased performance of the future engine. One possible advantage may be illustrated by Figure 9 which shows the effect of timing of the valve events on engine performance. One curve shows a timing to give a torque peak at comparatively low engine speeds approximately 800-1000 RPM; while the other curve is a typical torque curve of a high-speed passenger car type—timing giving a torque peak of approximately 2200 to 2400 RPM. These two curves may be combined in one engine by an automatic change in the camshaft timing controlled by speed, so that the final curve of the engine would be a curve shown by the dotted line combining the high torque characteristics of each curve. This will give a much better performing engine on the road.

Super Charging

We now come to the problem of supercharging and the results that we may expect from an engine with an integral

supercharger design. It is generally accepted that the roughness of an engine, with a compression ratio increased to take full advantage of the high-octane fuel, will be sharper and more objectionable than that of an engine which uses supercharging with a lower compression ratio to take full advantage of this same fuel. Since indicator cards taken on an actual engine run both with very high compression ratio and with a low compression ratio supercharged to approximately the same output are very difficult to obtain we would like to present here a few curves which are mathematical or ideal curves, the first of which shown in Figure 10, shows the ideal otto cycle with a compression ratio of 6:1. This you will notice has a peak pressure of 991.4 pounds per square inch and a peak temperature of 5497° F. These pressures and temperatures are, of course, theoretical and are never reached in an actual engine. Now let us consider that we are given a fuel of sufficient octane quality that we can run with a 10:1 compression ratio. Figure 11 shows peak pressures of 1830 pounds per square inch and 6129° F. temperature. This, on the theoretical card, shows an output of 117.8 percent of the first 6:1 card. Now then let us assume that we supercharge to 4 pounds per square inch and maintain the 6:1 nominal compression ratio. Figure 12 shows that we have peak pressure of 1227.1 pounds per square inch and peak temperature of 5724° F. showing 122.7 percent of the 6:1 output. From the shape of these cards, each of which would be considerably modified in an engine, you can readily see that peak pressures alone may cause a more objectionable roughness and perhaps the difference in temperatures might also be indicative of the difference in life expectancy of the parts exposed to the flame. Referring again to Figure 8 we can see that the octane requirement for a typical normally aspirated engine has a tendency to fall off with increase in speed. We may better be able to take advantage of the typical fuel characteristics of the fuels coming from so many of our refineries both in type and ratio that we may have

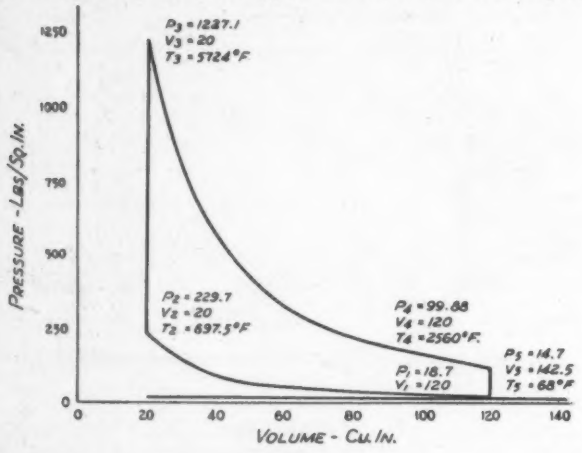


FIGURE 12
Otto Cycle Supercharged
Efficiency 51.08 percent; net work 2123.09 foot-pounds; output 122.7 percent of Ideal Otto 6:1 cycle.

little boost at the lower RPM's and gradually increasing boost at the speed increases. This would tend to give an engine octane-requirement characteristic which would more closely approximate a constant octane requirement. At the same time this type of boost will tend to increase the horsepower without materially increasing the peak torque outputs so that the entire drive train from the clutch through the transmission and rear axle would not have to be materially increased in strength and correspondingly in weight. Many of the improvements in engine units will have to be incorporated in this engine, for greater durability and ruggedness will be required due to the increased heat which each part must be able to withstand.

Sodium-cooled valves in all probability will be required for the exhaust, perhaps even the intake. Oil cooling of the piston may help to keep it in the correct shape and prevent burning. Necessary in today's engines—adequate cooling of the valve seats and combustion-chamber ports will be even more necessary in this supercharged engine. We must have intake ports designed to get a full charge into the cylinder with the lowest restriction and the exhaust ports designed

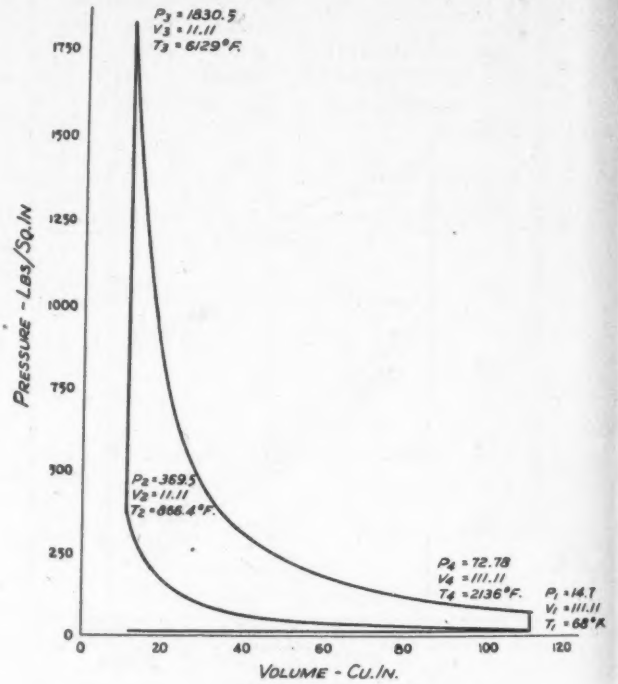


FIGURE 11
Ideal Otto Cycle
Compression ratio 10:1; net work, 2038.5 foot-pounds; output 117.8 percent of 6:1 Ideal Otto.

to get the exhaust gases out into the manifold with as little heat rejection to the water from them as it is possible with normal casting technique. It is every bit as important that we get the aforementioned good intake-port design and good valve lift with the supercharged engine as it is with the normally aspirated engine, for every unnecessary fraction of horsepower that is used in pumping is just so much loss and, therefore, so much inefficiency.

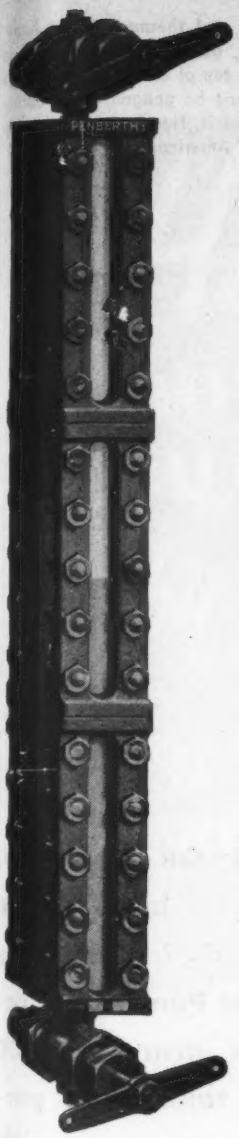
We may confidently expect the engine manufacturers to redesign their engines to take advantage of many of the improvements we know are developed today as well as those still in the development stage.

Fuel in itself as well as its influence on engine design will be the most outstanding contributor to higher efficiency and horsepower output.

Supercharging will be used in those operations and territories which require large power units.

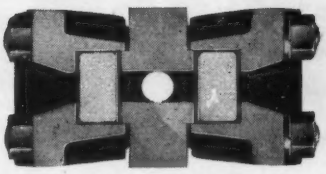
The manufacturers of the various component parts will keep up with and sometimes lead the demands of the engine manufacturer. Economics alone will force this for competition will be keen and "the devil takes the hindmost."

FOR EVERY GAGE REQUIREMENT



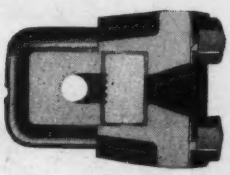
Whatever your liquid level gage requirements, there is a Penberthy Gage that will meet your needs. These gages are suitable for the various pressure and temperature conditions of the oil industry. All Penberthy Gages conform with A.P.I.-A.S.M.E. requirements.

Write for a copy of Catalog 34-A.



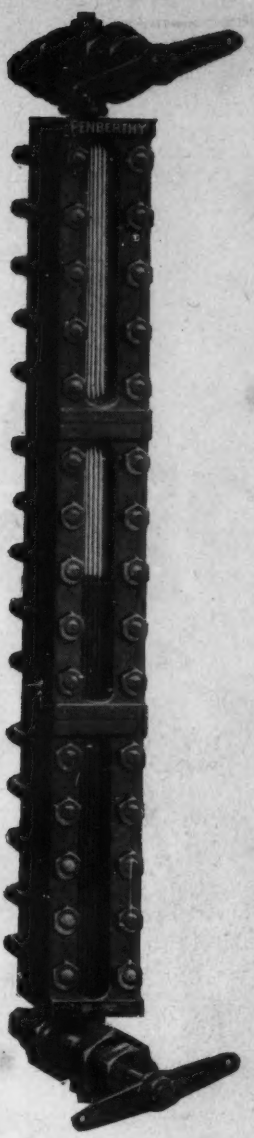
PENBERTHY
Transparent
DROP FORGED STEEL LIQUID LEVEL GAGES

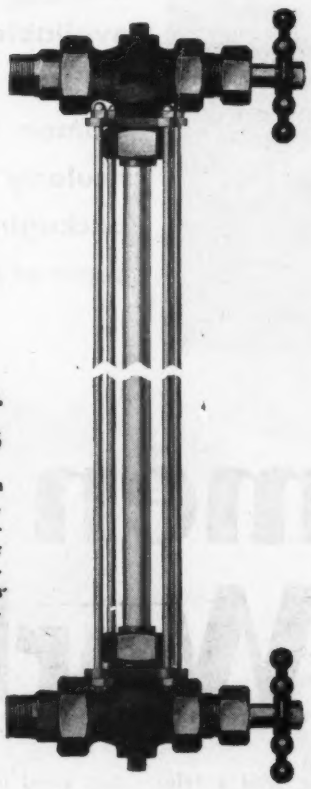
Used to observe color and density of liquids under high pressures, and/or temperatures. Construction is exceptionally rugged . . . . similar to Reflex types.



PENBERTHY *Reflex*
DROP FORGED STEEL LIQUID LEVEL GAGES

Liquid shows black — empty space shows white. Preferred wherever liquid level must be easily and positively visible . . . and when liquids are under high pressure or at high temperature.





PENBERTHY
DROP FORGED STEEL LIQUID LEVEL GAGES

Made of Chromium-molybdenum alloy temperature-resisting steel, extra heavy throughout. Stainless steel trimmed. Tubular glass type gages also available in various other metals suitable for practically all conditions.

PENBERTHY *Reflex*
WATER GAGE SET

Water shows black — steam shows white. U-Bolt construction is strongest and simplest to service. Glass replaced by simply removing nuts on face of gage . . . unnecessary to work between gage and boiler.

☆

THOSE PENBERTHY PRODUCTS

PENBERTHY INJECTOR CO.

DETROIT, MICHIGAN • **Canadian Plant: Windsor, Ontario**

With gauging tape and thermometer in hand, Mrs. Adah Lindsay, gauger, is shown here on her long trek to the top of a 10,000-barrel storage tank. Tanks must be gauged, fair weather or foul, but she likes it. Her husband and step son are with the American forces in Italy.

Continental Oil Company, when more men were needed and fewer were available at Ponca City, recruited an army of 300 women to take over, particularly in gauging and packaging — but they do some of the heavy work too.

Women Working

LITTLE more than a year ago, visitors entering the gates of Continental Oil Company's Ponca City, Oklahoma, refinery, would have seen an industry run almost entirely by men. The only women then employed in the plant were a few office workers and 28 company-trained women testers who had replaced men in the control laboratory.

Today 300 women are in the plant as a part of the company's 1031 women at war.

They are mothers, wives, sisters and sweethearts. Nearly all have men serving in the armed forces. Before Pearl Harbor these women war workers were engaged in varied activities. Many were housewives. Others were office workers, clerks in stores, school teachers, waitresses, high-school and college students. Mrs. Mila Wolfe, stenciler at the compounding and packing plant, spent 12 years as owner and manager of a restaurant business. Mrs. Lala Morris, lift-truck driver, formerly was a telephone switchboard operator, then a housewife.

When you ask these home-front fighters why they chose to enter a masculine industry, the reply is unanimous. "We want to help win this war." And, they mean it. Sure, war jobs pay good money. But, there has to be more incentive than cash when you tie into a job such as that held by Mrs. Mildred Walker, operator of the crane in the refinery machine shop. Working eight hours a day moving tons of heavy materials is a tough assignment. Ask any man who has done it. How's Mrs.

Here's why

THIS 1100 SERIES TUBE CLEANER by ELLIOTT

IS HANGING UP NEW SPEED RECORDS-

FASTER-

because of the following mighty good reasons —

1. Ball thrust bearing at rear of motor takes out rotor drag due to the push of the operator feeding into heavy coke —
2. Ball thrust bearing at the front of the motor prevents friction due to the pull of a self-feeding cutter head —
3. The exclusive Elliott lubrication system which brings a mist of oil to the bearing surfaces in the *front* of the motor, as well as to those in the rear, thus removing a common cause of friction, and even failure, in tube cleaners.

Practically all the power in this 1100 Series motor goes right into the job of smashing coke. That means much less still down time —as a good many refineries are discovering today. Details?

ELLIOTT COMPANY

TUBE CLEANER DEPT. SPRINGFIELD, OHIO

DISTRICT DIVISION OFFICES IN PRINCIPAL CITIES

Y-329

Mrs. Helen Earickson, "board woman," records data taken from the 100-octane-plant control board which serves the T.C.C. feed preparation fractionating equipment, alkylation fractionating equipment, and isomerization fractionating equipment.

Walker doing at the job? "Swell," say her supervisors. After the war, the woman crane operator plans to resume the household tasks she has left temporarily.

Most of the women are on the oil-production line so that they may help bring fighting men home quicker. Typical is Mrs. Golda Mooney, wife of Sgt. Charles Mooney now stationed in Hawaii. Mrs. Mooney, mother of two young children, is convinced that her job of filling barrels of oil and checking petroleum shipments will help hasten her husband's homecoming. And, when the sergeant returns, he is going to find that his wife has been postwar planning. With the aid of money earned by filling oil drums, Mrs. Mooney has paid for a home which she started to buy about a year ago.

Four Sisters

Della and Stella Durland, 19-year-old twins employed as fillers, are home-front fighting for their two brothers—Ed, in England, and Charles in the Gilbert Islands. On the same job with the twins are two other Durland sisters, Evelyn and Lucille, whose husbands are serving with the Army in England. While the four sisters work and share a two-room apartment in Ponca City, their parents grow victory foods on a farm near Broken Bow, Oklahoma, thereby completing an "all-out" family war effort.

It was March, 1943, when the first contingent of 15 women war workers was employed in the refinery compounding and packaging plant. Other than a small group of laboratory testers and a few office workers, those 15 were the first women refinery workers in the history of Continental Oil Company. Quickly they learned unfamiliar tasks like filling and stenciling and checking shipments of petroleum products destined for the war fronts and civilian markets. Later, more women were added to this staff, and others were assigned to similar tasks of barrel-filling and stenciling in the grease plant.

Then came the early days of 1944 and a manpower drain in both the refinery and the company's new 100-octane gasoline plant necessitated the addition of more women recruits. Subsequently, homemakers replaced men on such jobs as yardwork and maintenance, canning-machine operators, barrel cleaners, warehouse helpers, and tool-room attendants—to mention only a few of the jobs.

Mrs. Jo Adkinson, a postmistress at Grainola, Oklahoma, during the last war, jumped into the fight again this time as a boiler-fireman helper at the 100-octane plant. She and her husband, a veteran of World War I, have one daughter in high school and another who is a Link trainer instructor formerly employed at the Darr School of Aeronautics at Ponca City, until recently a trainer base for British and American fliers.

As man after man swapped industrial tools for fighting equipment, new groups of women rushed to answer the country's call for womanpower. Mrs. Vivian Lewis left a small farm near Ponca City to become gate checker at the refinery entrance. There she keeps an eye on each truck going into the refinery. When off shift, she spends several hours each month nursing the sick at a Ponca City hospital.

In Control Room

Mrs. Helen Earickson, a former waitress, became a "board woman" or control-board operator at the 100-octane plant. Her readings of the instruments, reports, and calculations are important factors in controlling the operation of the feed preparation and recovery unit of the high-octane plant. Mrs. Ola Marie Bartlett, a former office clerk, assumed similar responsibility as "board woman" for the thermofor catalytic unit. Mrs. Lois Hand, mother of four boys all under 10 years of age, became a casing machine operator in the grease plant when her husband joined the Army. It is the first job Mrs. Hand has had,

Both Mrs. Lois Hand, left, and Mrs. Lola Nelson, right, casing machine operators, are working at their first jobs. They plan to quit and resume household work immediately after the war.

SAFE

High pressures, high velocities, high temperatures . . . stresses and strains, corrosion and erosion . . . *all* factors which tend to undermine safety in piping are resisted by *Tube-Turn seamless welding fittings.*

Laboratory and field tests conducted regularly demonstrate how Tube Turns' *exclusive* forging processes increase serviceable life by improving grain structure in the metal itself, and thus reduce wear at the most vulnerable points of a piping system — where flow direction changes! Write for Catalog 111 — it contains data valuable to all who buy, specify and install piping and welding fittings.

VALUABLE WALL CHARTS

Dimensional data on Tube-Turn fittings and flanges are shown on these two handy wall charts, sizes 24 x 36 inches—sent free on request.

Selected Tube Turns Distributors in every principal city are ready to serve you from complete stocks.

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TUBE-TURN
TRADE MARK
Welding Fittings and Flanges

Viola Nutt, engineer's helper in the 100-octane-gasoline plant's compressor building, was photographed as she oiled a rocker-arm mechanism on a gas-driven compressor. Miss Nutt formerly was a taxi driver in Tonkawa, Oklahoma.

and she is doing it "just until the men come back." "When peace comes," Mrs. Hand emphasizes' "I'm going to take over my old job taking eare of the children."

Soon, the labor shortage eased somewhat as these, and other women, became modern minutemen and switched from home to home-front almost overnight.

Gaugers

All around the manufacturing department there is evidence of woman's knack in handling the tools of industry —of doing men's jobs well. Women gaugers climb refinery storage and "run-down" tanks to obtain samples. Women loader-helpers stand high on loading racks to help fill tank cars. On the loading docks and "cleanup" squads young girls just out of high school throw the same enthusiasm into war work as they used to put into the Friday night jitterbug session. Women, too, drive pickup trucks which shuttle on delivery trips between the refinery and 100-octane plant.

In the laboratories where 28 women testers worked little more than a year ago, there are now approximately 60, plus 4 women chemists who do analytical work in the control and gas-anaylsis laboratories. But, not all of the company's wartime conversions to woman-power have been in the manufacturing department. An even greater turnover has taken place in office personnel. The mailing and stationery division, once staffed entirely with males and one woman stenographer, now has 11 women and 3 men. Most offices have experienced a similar change. Everywhere in the organization women are picking up desk tasks left by men.

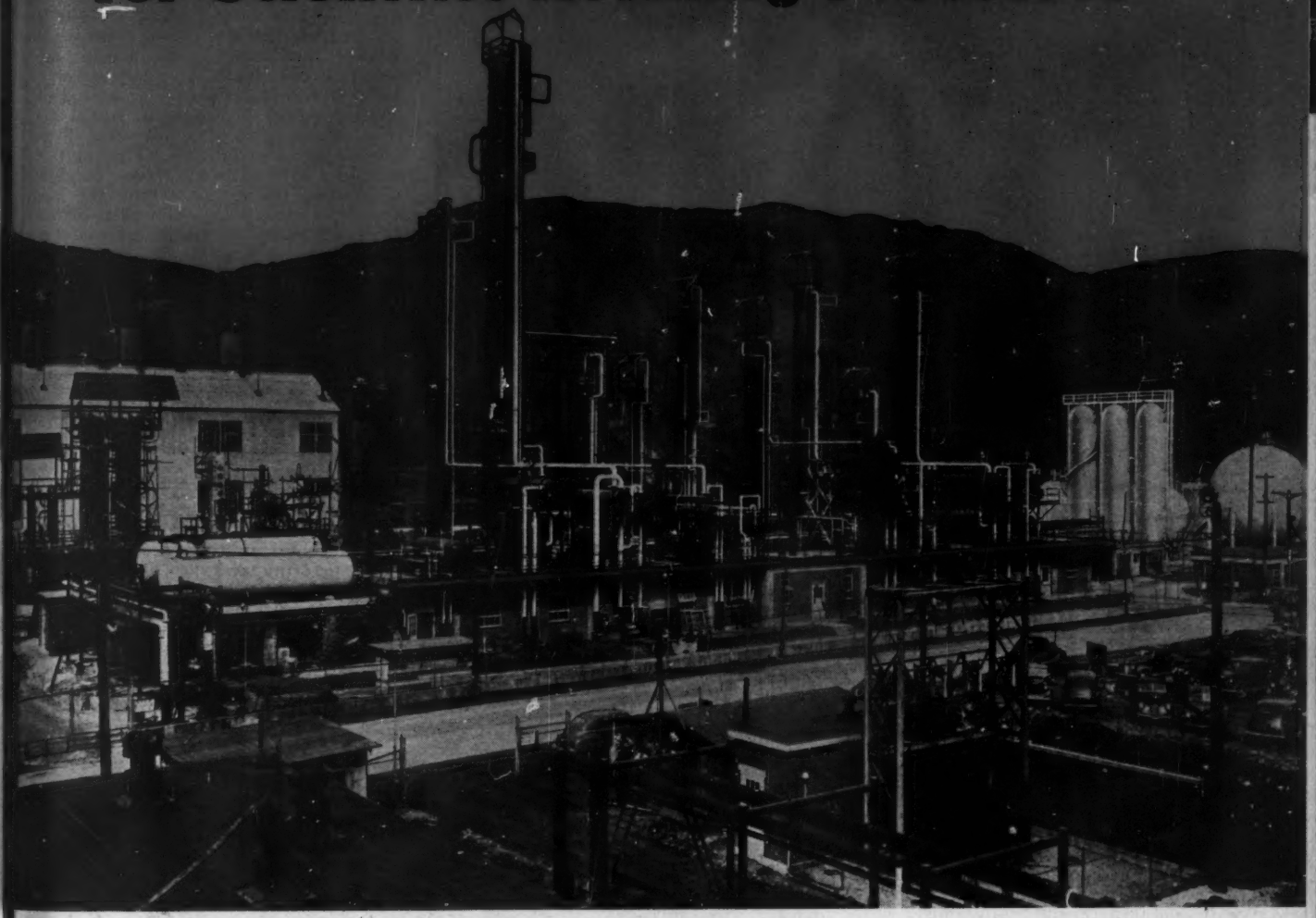
The five o'clock bell which closes the office day, and the refinery whistle which calls for shift changes at 7 a.m., 11 p.m., and 3 p.m., do not signify that the women's day is done. After work hours there are houses to be cleaned, clothes to be washed and mended, lunches to be packed, shopping to be done, and children to care for. Some of the women hire assistance for their home chores, but help is scarce.

Both the young and old, married and unmarried women spend many hours of their leisure time as nurses aides, Red Cross assistants, and U.S.O. hostesses. For other recreation many of them go to Continental Oil Company's gymnasium where badminton, roller skating, table tennis and other forms of athletic activity keep them physically fit for the jobs they must fill on the oil production front. War is serious business and these women war workers are out to win.

Below: Mrs. Helen Logwood, loader helper, is shown as she prepares to take a sample for the laboratory from a car of gasoline which has been loaded and is ready to leave the loading dock.

DESIGN ★ ENGINEERING ★ CONSTRUCTION

for Scientific Refining Processes



NEW refining techniques resulting from wartime developments have made the use of highly scientific processes and specialized facilities essential to successful refinery operation.

Arthur G. McKee & Company are prepared to design and construct new facilities to produce improved products and higher yields from your present crude supply.

McKee's wartime activities include the design and construction of plants for HF Alkylation, Dehydrogenation, Isomerization, Butadiene Extraction, Catalytic Cracking, Toluene Extraction and Precision Fractionation. McKee process specialists, engineers and technical experts can apply thorough, up-to-date knowlege of all modern processes to the engineering of your project,

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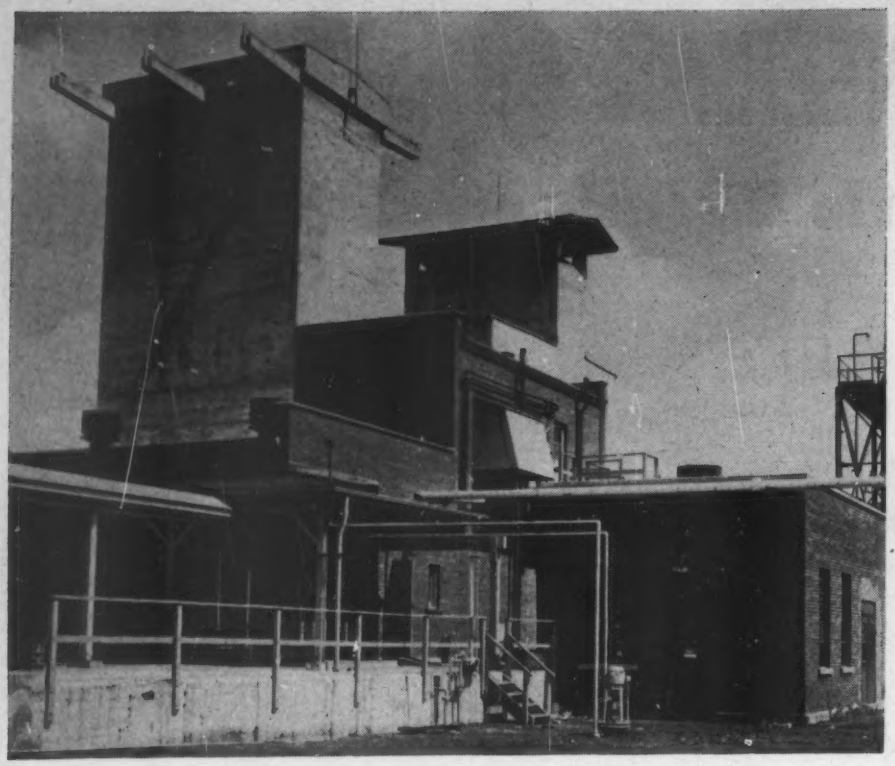


The two towers on the aviation fuel test stand of Standard Oil Development Company at Bayway, are intake and exhaust stacks for the cycline of air, used to cool the engine which is operated to simulate actual flight conditions.

Aircraft-Engine-Test Stand Completed At Bayway

STANDARD OIL COMPANY (New Jersey) put the first full-scale aircraft-engine-test stand for research on aviation fuels and lubricants up for public inspection at Bayway, September 19. Representatives of the press, Army and Navy and executives of aircraft manufacturing companies were guests of the company for an inspection of the new testing facilities. The event provided an opportunity for visiting the 100-octane-gasoline manufacturing facilities at the Bayway plant, talks by executives of Standard Oil Development Company at a luncheon, and finally a demonstration of an aircraft engine operating under condition simulating actual flight.

Technical information included a paper, "The Relation of Aviation Fuel Quality to Engine Performance," by Dr. W. J. Sweeney, Standard Oil Development Company, (printed in this issue of PETROLEUM REFINER Page 103); "Manufacturing Processes for High-Octane Aviation Gasoline," by E. V. Murphree, vice president of Standard Oil Development Company; "Aviation Engine Lubricants," by Dr. F. L. Miller, Standard Oil Development Company.

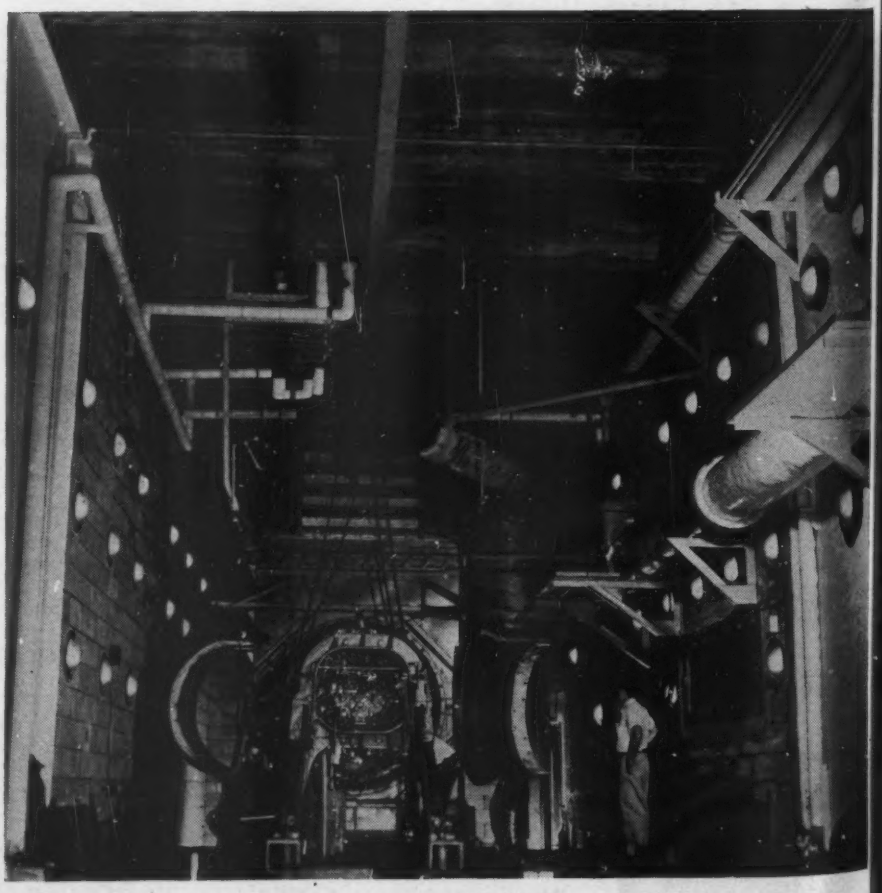
The engine-testing laboratory consists of 1500-horsepower airplane engine, mounted on a block of 240 tons of concrete, adjacent to a control room whose instruments are based on a separate foundation, supported on blocks of cork to absorb vibration. The engine, which is equipped with a dynamometer instead of a propeller, is controlled by instruments. The unit will provide information, from conditions simulating flight, concerning the power and performance of all fuels, including triptane. Some of these fuels are now made only in laboratories and in quantities insufficient for flight testing. Lubricants also can be tested.

Following is a part of the information made public at the demonstration:

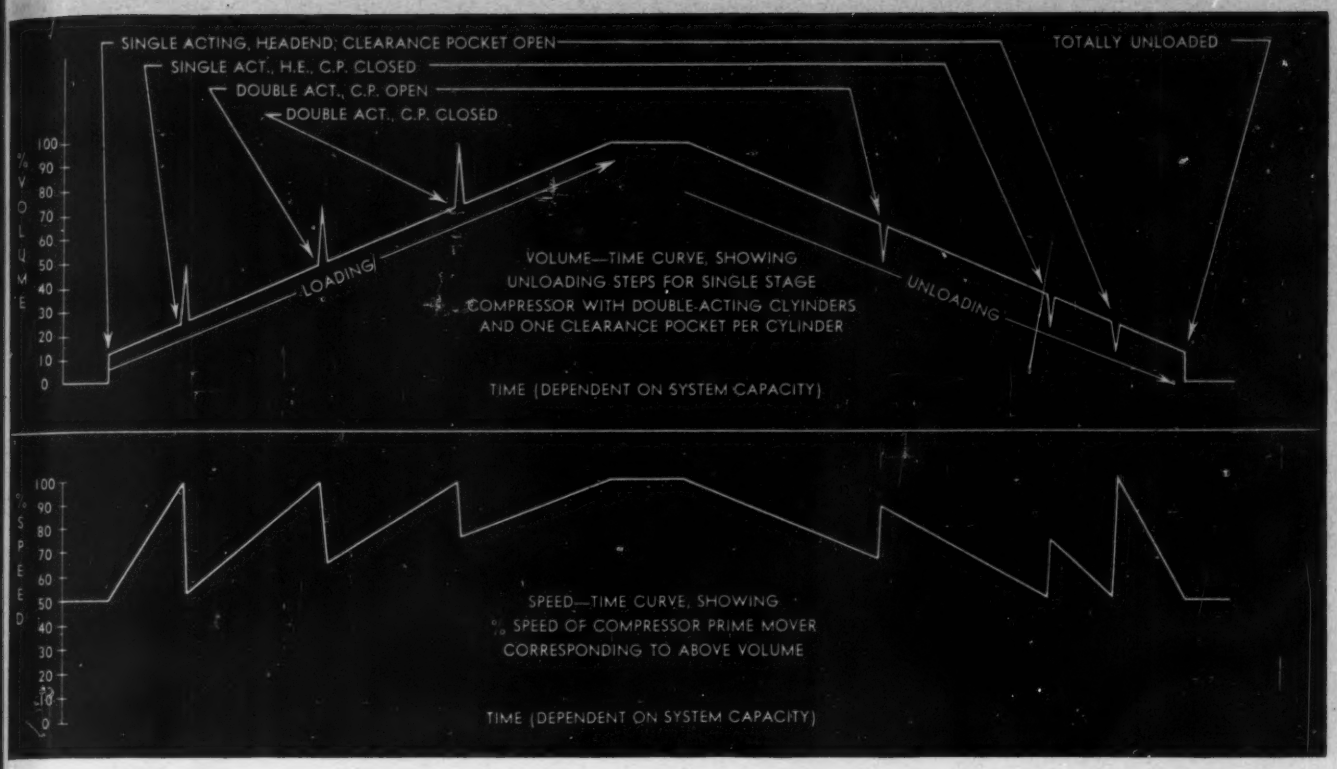
"Primarily, the operators of the test stand will attack the problem of aviation-engine knock, the same kind of knock that motorists hear in their engines if the octane number of their gasoline is too low. While that knock may only annoy the motorist and steal some power from him, it threatens the aviation engine with destruction in a few seconds.

"The chief limiting factor in aviation-fuel performance today is the tendency of the fuel to knock under increased power conditions. To date, the power of both automobile and airplane engines has been increased primarily by means which made the engine more demanding in anti-knock quality.

While the demands of airplane engines for this quality, expressed in oc-

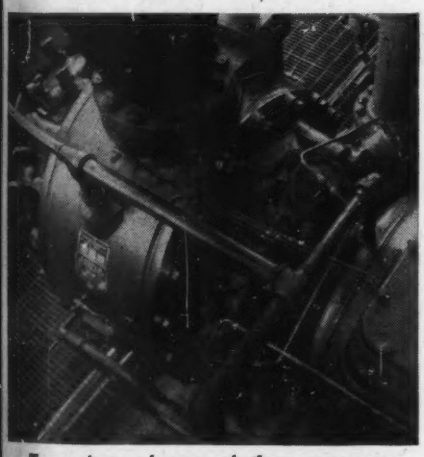


The test stand is designed to handle either liquid- or air-cooled engines, either pusher or tractor power plants. The engine is rigidly mounted close to the cooling-air duct on a tubular steel ring mount, simulating the mount provided on a plane. The ring mount is supported by a heavy cast-steel stand, secured by tee bolts on a massive cast-iron bed plate. The horsepower of the engine is measured by an eddy-current-absorption dynamometer. Engines of as much as 2,500 horsepower can be tested.



A BIG STEP FORWARD IN AUTOMATIC CONTROL

*Every stage of unloading is speed controlled!**



Top view of one of the compressor cylinders of an 800 hp G-MV compressor unit in a process application, showing pneumatic suction valve lifters.

COOPER-BESSEMER engineers have perfected a unique system that insures smooth compressor performance through full volume range. It will help any plant—chemical, refinery or other process industry—where compressors are called on to maintain extremely accurate, uniform pressures or flow rates under widely fluctuating loads.

Cooper-Bessemer has pioneered in control techniques as applied to compressors—control of pressures, flow rates, torque, etc. Now, a simple, reliable method has been developed to interpose speed control between the successive steps of unloading to give a straight-line control over approximately 100% demand. This new method of smoothly and accurately matching compressor capacity to process demand extends the advantages of speed control far below the limits previously practical with automatic control.

In the graph chart above, the volume-time curve and speed-time curve show how unloading combines with speed control to produce straight-line performance.

This new-type control is now available for all sizes of Type G-MV compressors. It does not require elaborate or expensively different equipment. If you have a control problem, drop us a line. Our representative will be glad to arrange for installation of this new Cooper-Bessemer control system when you order your new G-MV compressors.

*** Patent Applied for.**

G-MV COMPRESSORS

The Cooper-Bessemer Corporation

MOUNT VERNON, OHIO and GROVE CITY, PENNA.

Houston, Dallas, Greggton, Pampa and Odessa, Texas Shreveport St. Louis Los Angeles New York Tulsa Bradford, Pa. Parkersburg, W. Va. San Francisco, Cal. Seattle, Wash.

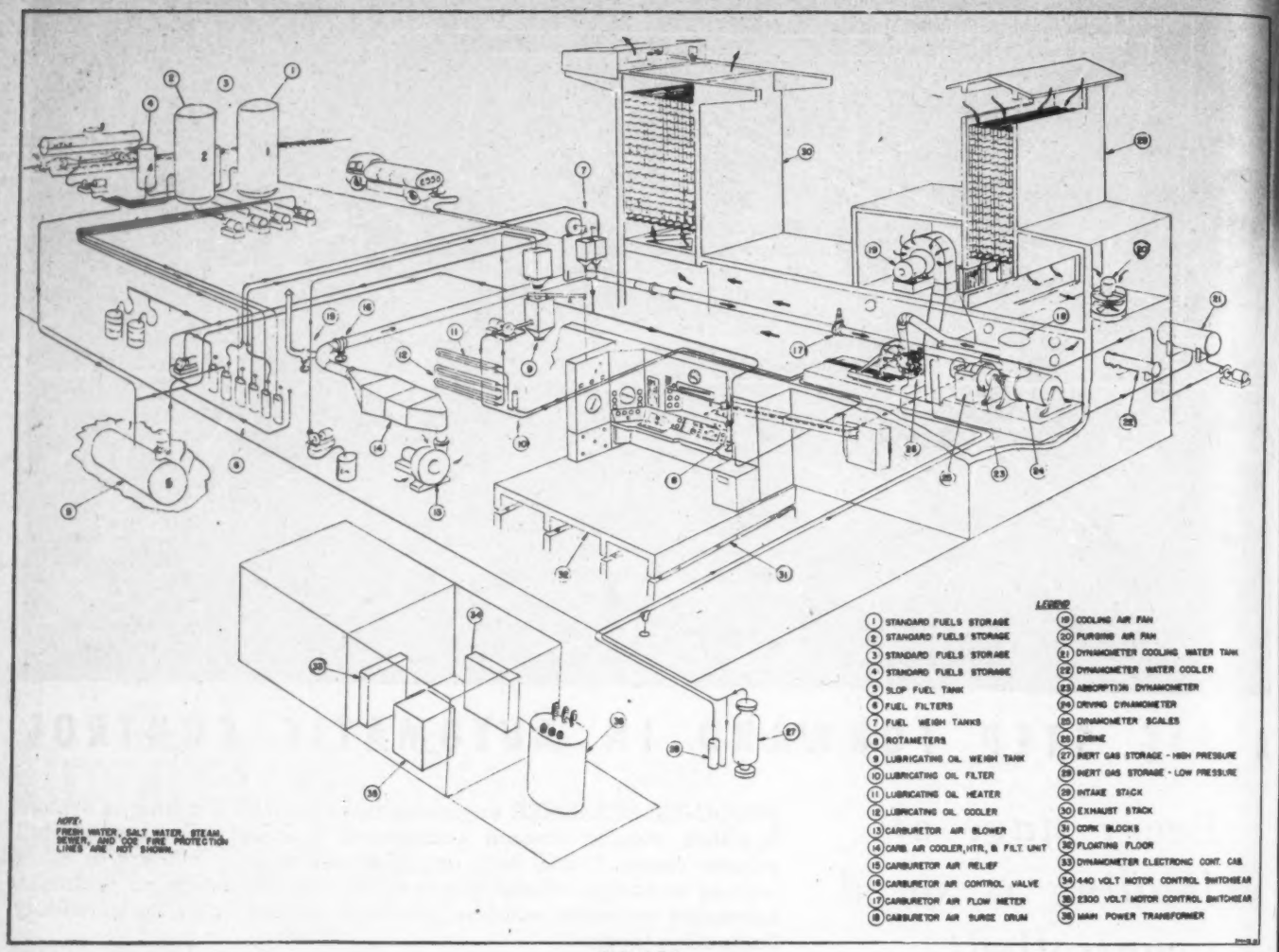

LEGEND
1 STANDARD FUELS STORAGE
2 STANDARD FUELS STORAGE
3 STANDARD FUELS STORAGE
4 STANDARD FUELS STORAGE
5 SLOP FUEL TANK
6 FUEL FILTERS
7 FUEL WEIGH TANKS
8 ROTAMETERS
9 LUBRICATING OIL WEIGH TANK
10 LUBRICATING OIL FILTER
11 LUBRICATING OIL HEATER
12 LUBRICATING OIL COOLER
13 CARBURETOR AIR BLOWER
14 CARB. AIR COOLER, HTR, & FILT. UNIT
15 CARBURETOR AIR RELIEF
16 CARBURETOR AIR CONTROL VALVE
17 CARBURETOR AIR FLOW METER
18 CARBURETOR AIR SURGE DRUM
19 COOLING AIR FAN
20 PURGING AIR FAN
21 DYNAMOMETER COOLING WATER TANK
22 DYNAMOMETER WATER COOLER
23 ABSORPTION DYNAMOMETER
24 DRIVING DYNAMOMETER
25 DYNAMOMETER SCALES
26 ENGINE
27 INERT GAS STORAGE - HIGH PRESSURE
28 INERT GAS STORAGE - LOW PRESSURE
29 INTAKE STACK
30 EXHAUST STACK
31 CORK BLOCKS
32 FLOATING FLOOR
33 DYNAMOMETER ELECTRONIC CONT. CAB
34 440 VOLT MOTOR CONTROL SWITCHGEAR
35 2300 VOLT MOTOR CONTROL SWITCHGEAR
36 MAIN POWER TRANSFORMER
NOTE:
FRESH WATER, SALT WATER, STEAM, SEWER, AND CO2 FIRE PROTECTION LINES ARE NOT SHOWN.

FIGURE 1

Design of the test stand facilities is shown in the diagram above, in which water, steam, sewer and fire protection lines have been eliminated. The main structure includes the test cell with intake and exhaust stacks, the control room, the equipment room, the service room and on mezzanine floors, two fan rooms, an air-filter chamber and a weigh-scale room.

tane numbers, greatly exceed the demands of automobile engines, the fuel improvements resulting from operation of the new test stand may ultimately contribute to the power and performance that the driver of the now 'futuristic' car will enjoy.

"Engines exceeding 2500 horsepower can be tested. Flight conditions are simulated. Huge blowers supply a cooling air stream which is closely regulated as to velocity and temperature. Air temperature can be maintained at 100° F., even though the initial air taken from outside may be as cold as zero F. Another blower supplies air for the carburetor with intricate controls regulating pressure and temperature over a wide range of flight conditions.

"Readings of temperatures on and in the engine can be automatically recorded from 48 points within a minute. This facilitates testing of expensive experimental fuels which can be made only in small quantities in the laboratory or in pilot-scale plants.

"Because of the intensity of sound produced by the engine no one can remain in the test stand room while an engine is in operation. Heavy soundproof construction of the walls and artificial sound-absorbing stone packed in the air inlet and outlet stacks greatly reduce the sound reaching the area outside. It is anticipated that sound coming out of the stack will have less than 1/256 of its original energy. This reduction in energy will prevent the sound, which is directed upward by the stacks, from being reflected by low hanging clouds and being heard in nearby residential communities.

"All test operation is automatically controlled in an adjoining instrument room which is protected from the intense sound in the test stand room by a 16-inch concrete wall in which there are no doors. For observation by the operators there are three windows in the wall, each of which has four panes of varying thickness to minimize sound transmission. Actually the roar of the engine can hardly be heard in the control room. The control room floor on which the instruments are based is isolated from the rest of the structure by being built as a seperate unit supported on blocks of cork to absorb vibration.

"Instead of delivering power to a propeller, the test engine is connected to a dynamometer which both absorbs the power and measures it. The dynamometer is electronically controlled to meet exacting research standards. Two fire-protection systems, both using inert gas, have been installed.

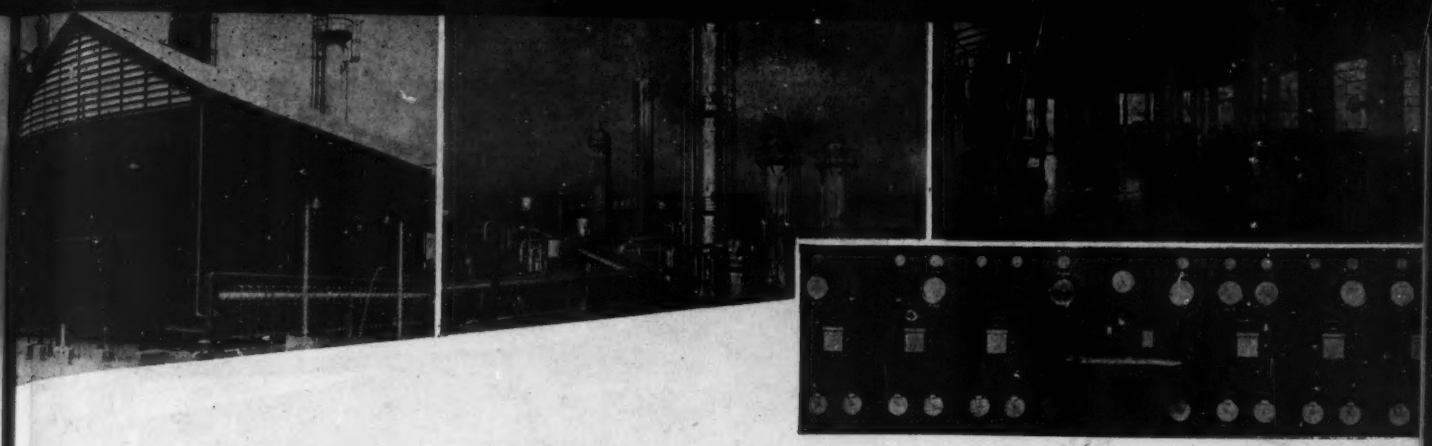
"An intricate system of lines, valves, weigh tanks, and automatic, inter-locking controls handles the supplying of accurate amounts of fuel and oil to the test engine. In addition to the operation of the engine for fuel tests, aviation lubricants will also be tested.

"The test stand as now completed, with its special accessory facilities, is believed to be the finest aviation test stand in existence for quick and accurate studies, such as:

"1. The testing in actual engines of exploratory fuel blends to evaluate existing processes for making high-octane aviation gasoline components, and more particularly new processes, thus enabling decisions to be made as to desirability for commercial production. It will also permit the evaluation on a relative basis of the components now available for the blending of aviation gasoline. It is of the greatest importance that multicylinder investigations be carried out so that the necessary decisions on manufacturing can be made well in advance of the day when volume production is needed, and that such decisions be the correct ones to insure, from available raw materials, the largest volume of fuel of the desired quality.

"2. Influence of engine operating variables on fuel performance and anti-knock behavior, e.g., effect of speed, spark advance, mixture ratio and automatic ratio control, temperature, compression ratio, and pressure as influenced by supercharger (blower) gear ratio, etc.

"3. Anti-knock requirements of engines operating under combinations of the above variables, and particularly those combinations found to exist in practice. Present knowledge of this score is inadequate.



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REPEAT BUSINESS has constituted 60% of our contracts in the last six years.

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CALL US AT TULSA L.D. 410

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Valves and Fittings

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Instruments

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Since doors and windows are the foremost source of leakage in sound-proof walls, only windows were provided between the test cell and the control room. The three windows are each built with four panes of special glass employing dessicants to dry the space between the panes to avoid clouding from condensation. On the control-room side the first pane is laminated shatter-proof glass. Glass of the other three panes is special type of high strength, which when fractured does not shatter to form sharp splinters but disintegrates into small pieces and beads without sharp corners.

"4. Fuel-to-cylinder distribution pattern of engines operating under combinations of above variables, when using fuels of different volatility characteristics.

"5. Closely allied with the preceding study would be the influence of distribution on the behavior of fuels having anti-knock quality controlled within the distillation range and thereby permit of setting a specification to insure optimum performance over a wide range of conditions."

The test stand, which cost $500,000, was built as a company venture. It was designed after study of existing test stands of engine manufacturers. Material was made available after facilities for making aviation gasoline and synthetic rubber ingredients were assured. Previously facilities of engine manufacturers and governmental agencies had been used for testing fuels. These had become inadequate for fuel-quality testing. The effect of lack of facilities was summed up in the official release with this observation: "The inevitable result is that the work on fuels has been far from complete. There is little doubt that, lacking the time and facilities for very close control, aviation-fuel specifications have been set with a liberal factor of safety and the volume of aviation gasoline production may have been limited thereby."

BAYWAY NOT BAYTOWN

Habit-building forces that come from long association had its way in the September Petroleum Refiner, wherein the accomplishments of a training program in the Bayway plant of Standard Oil Company of New Jersey were shifted to Baytown. From the composing room, through the proof room and back to the desks in the editorial office the error went its unnoticed route and back to the press and page 103 of the issue. At each point men were so familiar with Baytown and the plant of Humble Oil & Refining Company that Bayway and the plant of Standard Oil Company of New Jersey made no impression.

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Invention and the Oil Industry

DR. GUSTAV EGLOFF
Universal Oil Products Company

THE oil industry of the world has reached its greatest development in the United States. This growth has been achieved largely through the incentive to invent, and the protection to inventions afforded by the American patent system. In fact, the oil industry's tremendous importance in the war rests squarely upon inventions protected by patents. The manufacture of adequate amounts of 100 plus aviation gasoline for fighter, bomber, and transport planes has involved the use of many inventions for producing its ingredients. Toluene needed for TNT manufacture has been made available through the application of new processes. Synthetic rubbers and a multitude of other products have had to depend to a great extent on processes stemming from inventions in petroleum refining. The protection given by our patent system has encouraged the enormous amount of research that fashioned the oil industry into a mighty war weapon.

In 1859 the completion of the Drake well marked the beginning of the oil industry and the kerosine age. Drilling of other wells, the transportation, storage, and refining of the oil into marketable products immediately presented an array of new problems which required the exercise of the inventive faculties of many men for their solution. New tools, new equipment, and new processes followed, which made possible drilling at increased depths, safer storage, more rapid transportation, and the breakup of the crudes into better kerosines, lubricants, and waxes. The patent records of this early period show how the publication of each new step stimulated further inventions, both in oil refining and in related fields, such as the manufacture of kerosine lamps.

From its modest beginning of 25 barrels a day, the oil industry has grown in the United States so that it is now producing about 4,700,000 barrels daily. At the present time the petroleum business represents an investment of over $15,000,000,000. This growth was stimulated by patent protection.

Finding Uncertain

The first step in the industry, that of finding the oil, is always an uncertain undertaking in which there are many more failures than successes. However, in this initial phase of the industry invention has eliminated some of the uncertainty which the wildcatter faces in his search for new fields. Geological, geophysical, electrical, and chemical methods have been invented which are exceedingly helpful in locating possible oil-bearing structures. Even now, after locating a potential oil field by all available methods, the driller may bring forth oil, gas, hot water, or nothing. In 1937, 1 out of every 10 wildcat wells produced oil, while in 1942, as more scientific methods of exploration were used, the ratio of producing wells had so increased that 1 out of 6 wildcat wells yielded petroleum. As further inventions are made, the finding of oil will become more certain.

To summarize, what has invention done for the oil industry?

It has conserved 20,000,000,000 barrels of crude oil.

It has developed new fuels of great energy to increase the power output of motor cars and airplanes.

It has increased the supply of toluene for making the high explosive, TNT.

It has made possible an American synthetic rubber industry which frees us forever from dependence on rubber trees.

It has afforded employment to more than 1,000,000 men and women in research, development, and pilot-plant laboratories; and in the operation of numerous commercial processes.

It has spurred competition in the oil industry, and competition means progress.

It has fostered the development of many new industries and the enlargement of old ones outside the oil industry to supply needed equipment and products for petroleum processes.

It has furnished basic materials for the manufacture of large numbers of chemical derivatives and thus fostered a new chemical industry.

It is one of the prime factors in winning the victory for the United Nations.

It is the incentive to even greater achievements in the postwar period.

The first well drilled for oil in the United States produced at a depth of 69 feet. Today, wells are producing at depths of over 2½ miles, and others have penetrated the earth's crust for about 3 miles, although the latter have thus far been dry holes. Reaching these depths has been made possible by the invention of specialized drilling machinery. Whole new industries have been developed to supply the mechanical equipment and chemicals needed in this work, and inventions have been encouraged in fields far removed from petroleum. Bits made from alloys of exceptional hardness, developed through years of research, bore through all kinds of structures at high speeds. These tools are cooled by special colloidal mud mixtures which serve also to control the well pressure. Methods for drilling wells in any direction and to any level desired have been invented so that formations at different depths can be tapped from the floor of a single derrick. As many as 13 different oil horizons are found in some fields. It took inventiveness of a high order to make possible the drilling of wells 3 miles deep without deviating more than 2 degrees from the vertical.

Breaking Emulsions

In the production of crude oil, water or brines are generally encountered. As oil and water come up through the well pipe together they form emulsions, presenting another difficulty which has been overcome by invention. Of a total 2,250,000,000 barrels of crude oil produced throughout the world in the war year 1943, an estimated 500,000,000 barrels were persistent oil-water emulsions of various types. Many of these are extremely difficult to break, but the oil must be separated from the water before it is refined. Invention has also triumphed over this problem. No one method has been found satisfactory for all oils. Physical, chemical, electrical, and mechanical processes have been successfully adapted to resolving the various types of emulsions into oil and water.

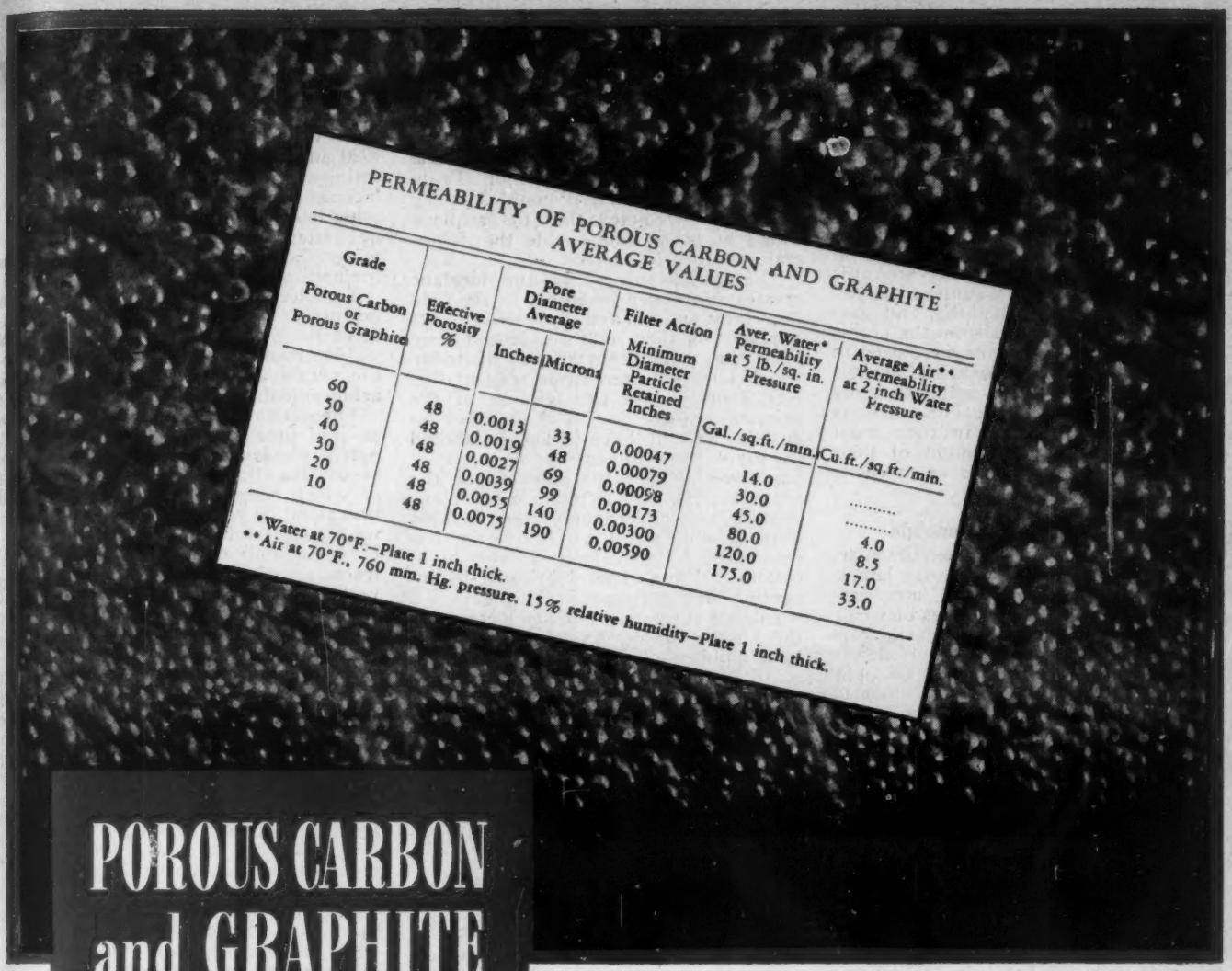
Special Storage Tanks

The advent of low-boiling petroleum products has necessitated the development of special types of storage tanks to hold them. Inventors have found this field to be a fertile one for their ideas. Tank storage for crude oil and gases at wells, refineries, and bulk stations has also called for constant research. Some storage reservoirs hold as much as 3,000,000 barrels of crude oil. Floating roofs and breather devices conserve gasoline. Spherical and spheroidal tanks have been invented for the storage of liquefied hydrocarbon gases under pressure. The largest spherical tank in use today is 60 feet in diameter and holds 20,000 barrels under pressure of 60 pounds per square inch. Spheroidal tanks of 155-foot diameter have been built to hold 120,000 barrels of gasoline. Such tanks are used to store butanes, butylenes, and butadiene, raw materials for aviation gasoline and synthetic rubber.

Pipe lines provide a method of transportation peculiar to the oil industry; they were developed exclusively by it, and developments in this field are not yet at an end. The process of centrifugal casting has been employed to make stronger pipe. Many methods have been developed for preventing internal and external corrosion of the pipe. Machines for wrapping pipe lines with tar-saturated fabrics are used, and systems of cathodic protection are employed in acid and alkaline soils. Long sections of field pipe lines are periodically cleaned out by forcing cleaner plugs ahead of oil or water. The transportation of oil by tankers from the Gulf to the Eastern seaboard was seriously curtailed by submarine activity during the early part of the war. To overcome this situation, the largest pipe line in the world, 1500 miles long, was built in record time and now conveys 300,000 barrels of crude oil per day. It extends from Longview, Texas, to New York. The pipe line is 24 inches in diameter and is equipped with specially designed oil pumps of huge size. The completion of this project would have been impossible without the previous researches and inventions which speeded the laying of the line through swamps, over mountains, and under roads and rivers.

Most Baffling Mixtures

Crude oil is one of the most baffling mixtures found in nature. Its physical



PERMEABILITY OF POROUS CARBON AND GRAPHITE
AVERAGE VALUES

Grade Porous Carbon or Porous Graphite	Effective Porosity %	Pore Diameter Average Inches	Pore Diameter Average Microns	Filter Action Minimum Diameter Particle Retained Inches	Aver. Water* Permeability at 5 lb./sq. in. Pressure Gal./sq.ft./min.	Average Air** Permeability at 2 inch Water Pressure Cu.ft./sq.ft./min.
60	48	0.0013	33	0.00047	14.0	.....
50	48	0.0019	48	0.00079	30.0	.....
40	48	0.0027	69	0.00098	45.0	4.0
30	48	0.0039	99	0.00173	80.0	8.5
20	48	0.0055	140	0.00300	120.0	17.0
10	48	0.0075	190	0.00590	175.0	33.0

*Water at 70°F.—Plate 1 inch thick.
**Air at 70°F., 760 mm. Hg. pressure. 15% relative humidity—Plate 1 inch thick.

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characteristics are extremely variable, and its chemical composition is exceedingly complex. Early research occupied itself chiefly with the efficient physical separation of the components of these mixtures, but the inquiring inventor soon found that such separations were not the complete solution of the problem of obtaining the greatest values from petroleum.

In the early years of the petroleum industry, the values inherent in crude oil were neither fully recognized nor utilized. Simple distillations sufficed to fractionate the kerosine, naphtha, and gasoil as principal products from the crude. Other physical separations were used to recover lubricating oil, wax, and asphalt from the residue in the small amounts called for in that period. The fractions of the crudes were put to their most obvious uses without thought of their conversion into new types of products not yet in demand.

Development of Automobile

The principal and most readily marketable product was kerosine for lamps. This first supplemented and later supplanted the inadequate supplies of whale and fish oils, and oils produced from coal and shale, so that this period was known as the "kerosine age." Gasoline in this era had no commercial value to speak of, and what could not be forced into the kerosine fractions was burned or dumped into the rivers. This hazardous practice accounted for some serious fires. As a shortage of kerosine developed, a part of the crude oil was thermally cracked at relatively low temperatures and pressures to increase the yield.

In 1895 there were but four motor vehicles registered in the United States. However, production increased rapidly, and it may be said that the "gasoline age" began about the turn of the century. The inventions which made possible the commercial development of the automobile, and the rapid expansion of the automotive industry, put pressure on the oil industry to invent processes for the manufacture of more gasoline and better lubricants. Through its inventions the oil industry was able both to produce more crude and to increase the yield of motor fuel from each barrel. The increased supplies of gasoline made possible the expansion of the automotive industry. Inventors in the field of engines for automobiles, busses, and trucks have been engaged in bringing out new engines requiring higher anti-knock fuels and better lubricants than those formed underground by nature. The new engines spurred the oil industry to still greater efforts to meet their demands.

Airplanes Stimulate Engine Development

From 1900 to 1941 the number of motor driven vehicles in the United States had increased from 8000 to around 33,000,000. This difference accounts for the correspondingly great increase in demand for motor fuel. The total production of gasoline from crude oil in 1900 was around 8,000,000 barrels, while in 1941 it was over 640,000,000 barrels. In 1900, a greater proportion of the gasoline produced was used for other purposes than automotive fuel, a fact which accounts for the apparent discrepancy in the consumption per car between 1900 and 1941.

At about the same time that the automobile became a potent factor in the national economy, the airplane became a reality and began to seek its place in the sun. Although the results of the Wright brothers' first flight in 1903 with a heavier-than-air machine were not as immediate and wide-spread as in the case of the automobile, the airplane was an epoch-making invention. From its humble beginning it could scarcely have been predicted that the airplane would at some time enable the democratic nations to survive.

The initial success of the airplane greatly stimulated inventors in the field of aircraft engines and plane designs. As a result of their many inventions we have the magnificent planes of today which have so altered our way of life. Not alone within the borders of the aviation industry, but in many other industries as well, have inventors labored to supply the increasing demands of air travel. Under the impetus of the present conflict the airplane and airplane engines have undergone extremely rapid development, and the oil industry has responded to the demands for high-octane fuel and super lubricants by inventing new processes.

In 1903 there was but one airplane in the United States. As late as 1927 the total number of airplanes manufactured was 1785. Under the stimulus of war, production of military airplanes increased rapidly to 12,636 in 1940, 49,000 in 1942, and 86,000 in 1943. At the present rate, United States production in 1944 will be about 95,000 planes. However, numbers alone do not tell the whole story. The size and carrying capacities of planes have undergone great increases. On this basis it has been estimated that the 1943 production actually more than doubled that of 1942. There seems to be no limit to the size of projected aircraft. The Hughes-Kaiser 400,000-pound flying boat which is now approaching completion, will carry over 125,000 pounds. Far larger planes are in the making.

The aviation industry is still impelling the oil industry to invent processes for making both gasoline and lubricants that have still better performance characteristics in airplanes. This mandate has provided a high incentive for new researches. Practically all aviation gasoline is made by catalytic processes, and a great percentage of the components of aviation-fuel blends are synthetics.

The change in the quantities of products from petroleum during the transition from the "kerosine" to the "gasoline age" is shown in the following table:

Crude Produced in the U. S. and Average Volume Percent Yield of Products Per Barrel of Crude
(M = 1,000 Barrels)

	1900		1920		1940	
	M Bbls.	Percent	M Bbls.	Percent	M Bbls.	Percent
Crude oil	63,600	100	443,000	100	1,352,000	100
Products:						
Gasoline	8,210	12.9	114,000	25.7	591,000	43.7
Kerosine	36,600	57.6	44,200	10.0	77,000	5.7
Lubricating oils	4,840	7.6	39,800	9.0	37,800	2.8
Distillate oils	.....	....	.....	....	192,000	14.2
Heavy oils	8,910	14.0	221,500	50.0	330,000	24.4
Miscellaneous	5,010	7.9	23,500	5.3	124,200	9.2

Gasoline Yield Increase

The percentage yield of gasoline from crude oil almost quadrupled between 1900 and 1940, and the total volume of gasoline increased 75 times. The yield of kerosine from crude in the same period decreased from 57 to 5.7 percent, although the total volume of kerosine doubled because of increased crude-oil production. The percentage of lubricants from crude went through a maximum of 9 percent in 1920 and dropped to about 3 percent in 1940, although the total volume was about the same in 1920 and 1940. This constancy in lubricating-oil volume, in the face of greatly increased numbers of automobiles and other motor vehicles, is accounted for by better qualities of lubricants, their more efficient use, and recovery systems for used oils.

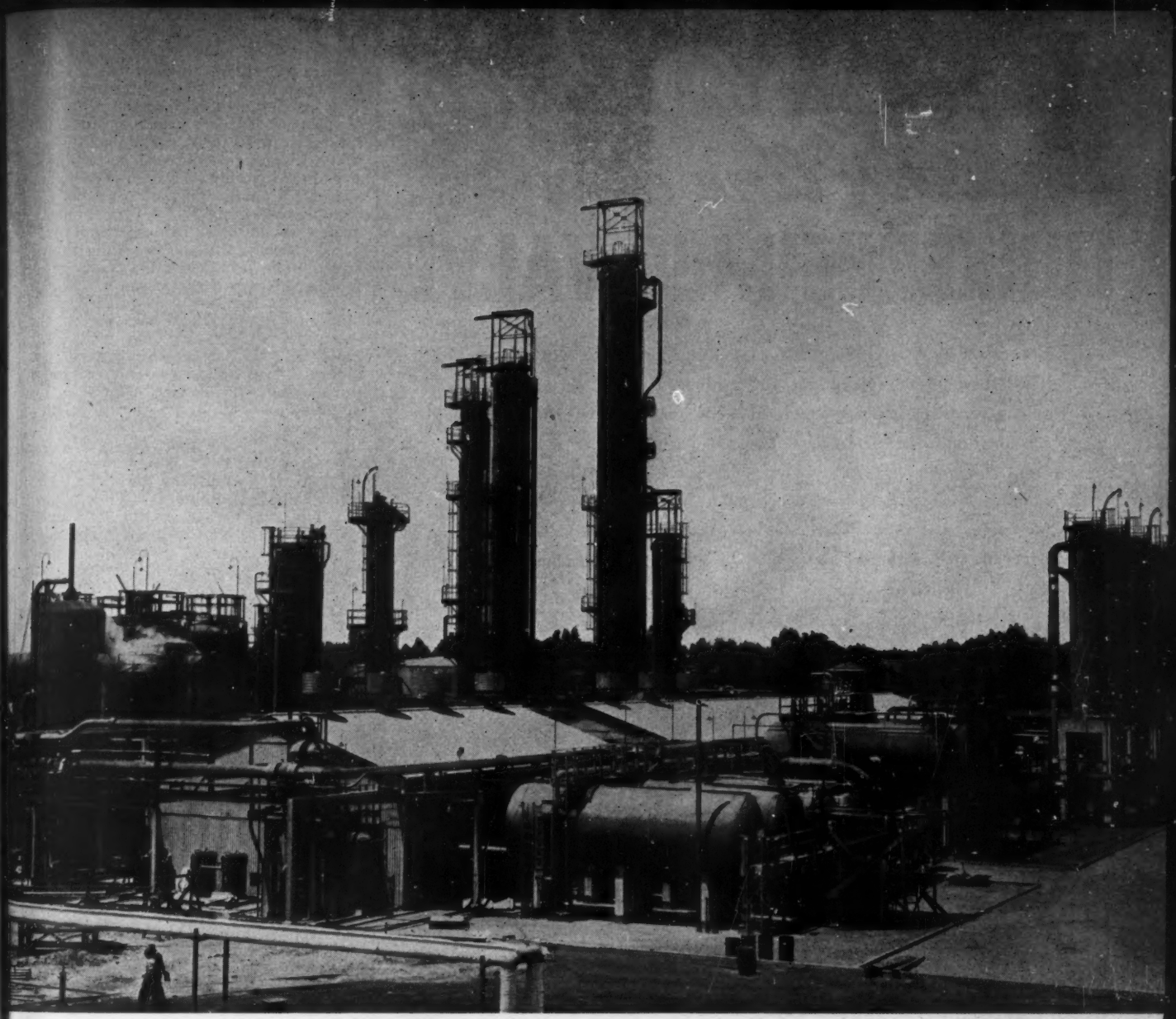
The need for more gasoline spurred inventors to redouble their efforts to solve the problem of producing greater yields from crude oil. The patents of the period are a record of their signal achievements in this direction.

The outstanding fruit of inventiveness at this time was the Burton thermal batch cracking process and its successor the Burton-Clark process, both of which went into commercial operation about 30 years ago. These processes were successfully used for many years. However, only the more selected gasoil fractions of the crude could be converted into gasoline with a yield of about 30 percent. These processes were the first step in a long march. Step 2 was the invention of the Trumble process which was the first to give relative continuity to the cracking process, but could not produce gasoline commercially unless the charging stock was gasoil and the yields thereof limited to within the same range as the Burton and Burton-Clark, and which was exemplified in such processes as those licensed by the Jenkins Petroleum Company. The following step was the invention and perfection of the Dubbs clean-circulation cracking process which, as compared with Burton-Clark or Trumble, more than doubled the yield of gasoline from crude oil by cracking heavy residues as well as gasoil in a continuous manner, and which superseded all its predecessors.

Thermal Cracking Conserves Oil

Since its commercialization, the thermal cracking of oil has conserved about 20,000,000,000 barrels of crude petroleum, which is about our present estimated oil reserve. Had it not been for the cracking process it would have been necessary to produce 45,000,000,000 barrels of crude oil instead of the 25,000,000,000 actually produced. The quality of the cracked gasoline produced has been far superior to that of the natural product, and more actual power has been obtained from gasoline engines than the increase in gasoline indicates.

Gasoline derived from the distillation of crude oil has an average octane rating of about 52, while in contrast, thermally-cracked gasoline has a rating of about 70. Cracked gasoline of this latter octane rating gives a 25 percent



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greater power output than nature's product when used in motors designed for it. This conserves a corresponding amount of fuel. A further increase in octane rating from 70 to 80 makes possible another 13 percent increase in power and a proportionately lower fuel consumption. Continually increasing octane numbers, brought about by the application of new inventions to the manufacture of gasoline, have made possible the development of high-compression engines which power war-planes.

To meet the demands for higher octane numbers, research men turned their attention to breaking down petroleum molecules and recombining the fragments to produce structures having forms and sizes better suited to the engine. Having solved the problem of supplying motor fuel in sufficient quantity, the inquiring light of research was turned toward still further improvement in quality, and to the development of totally new products.

While thermal cracking, continually improved and kept up-to-date, is still an important factor in the refining industry, far-seeing research leaders years ago sensed the fact that thermal cracking had its economic limitations as to the quality of the gasoline which it could produce; accordingly they pioneered in the investigation and study of a factor new in refining, namely, catalysis.

Catalysts

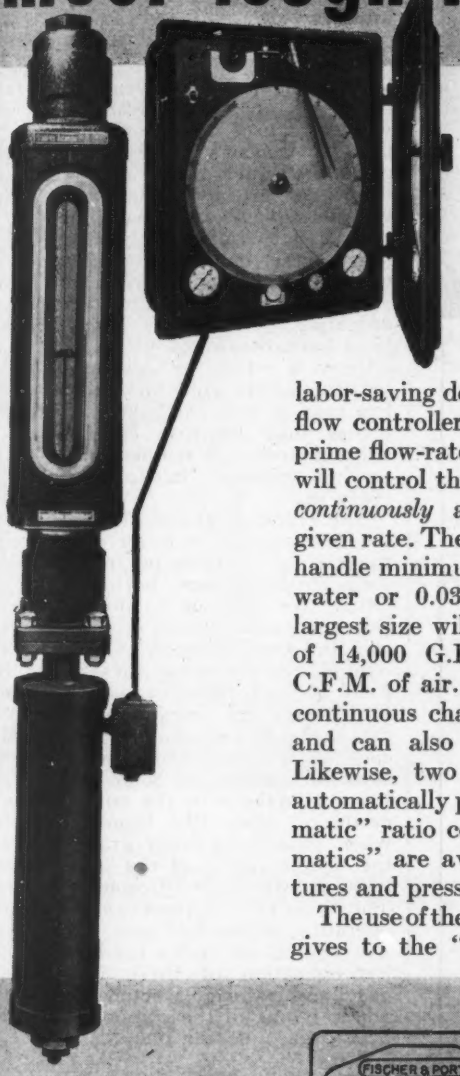
Early catalytic cracking processes used a variety of catalysts. Notable among these were aluminum chloride and the oxides of iron and other metals. In subsequent developments aluminum silicate minerals were employed, and still later, silica-alumina complexes of an active and at the same time a refractory character were invented. The need for developing catalysts has challenged the ingenuity of many inventors, and the catalysts which they have made have had a profound effect on the war effort in producing increased amounts of 100-octane aviation fuel and synthetic-rubber hydrocarbons. In 1938 the total consumption of aviation fuel in the United States by military, commercial, and privately-owned planes was 2,391,629 barrels, a rate of about 6500 barrels a day. The average octane number was about 83. In December, 1941, at the outbreak of war with Japan, production of aviation gasoline was around 40,000 barrels a day, while at the present time warplanes are being supplied with more than 500,000 barrels daily, much of which is of 100-plus-octane quality.

Methods of catalyst utilization in cracking have also undergone extensive modifications. Four types of processes are now in commercial operation, the static bed, moving bed, fluid flow, and slurry. Many inventors have contributed to the commercial success of catalytic cracking.

Catalytic cracking produces gasoline of 80-octane number or higher, and gives better yields than thermal cracking. The gases from catalytic cracking contain considerably greater amounts of isobutane, the key hydrocarbon needed in the production of alkylate for aviation-fuel blends.

Cracked gasoline produced either by thermal or catalytic processes has a tendency to oxidize in storage, producing gum which impairs the operation of engines. Inventors who attacked this problem developed powerful chemicals known as inhibitors, which protect gaso-

Here's a suggestion to help you meet tough Post-War Competition!



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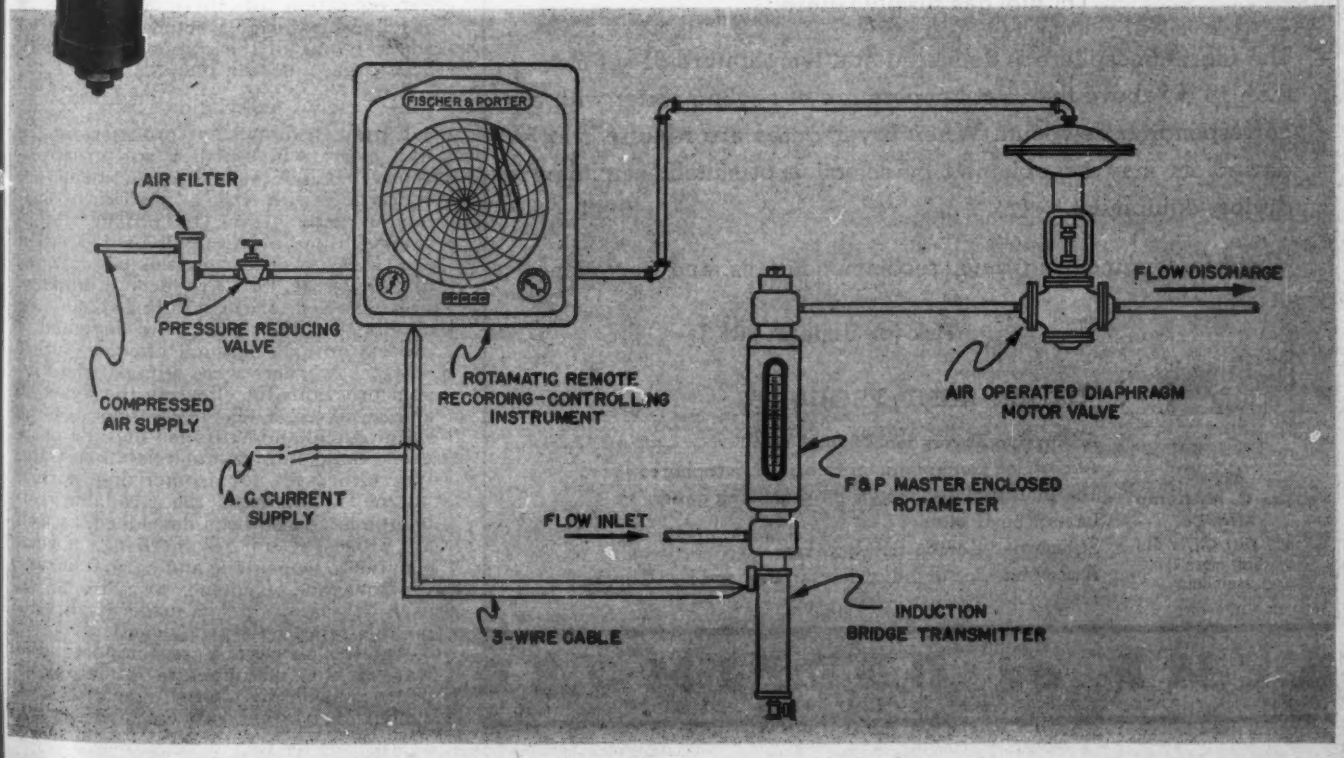

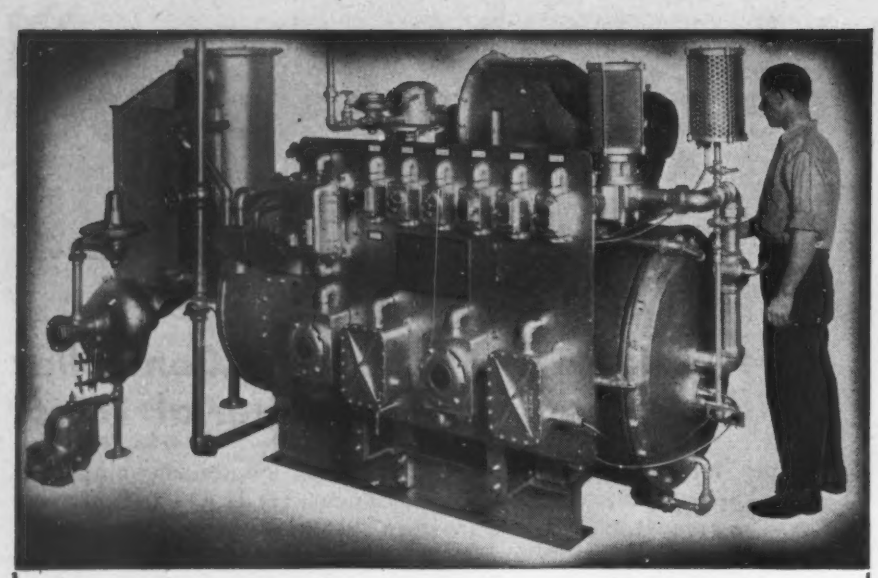

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line from degradation during long periods of storage by preventing formation of gum and preserving the anti-knock value. The use of inhibitors has materially assisted in the conservation of petroleum, since it has obviated the necessity of extensive chemical treatment of cracked gasolines and has conserved valuable anti-knock properties. About 75 percent of all gasolines now contain inhibitors.

Improved Lubricants

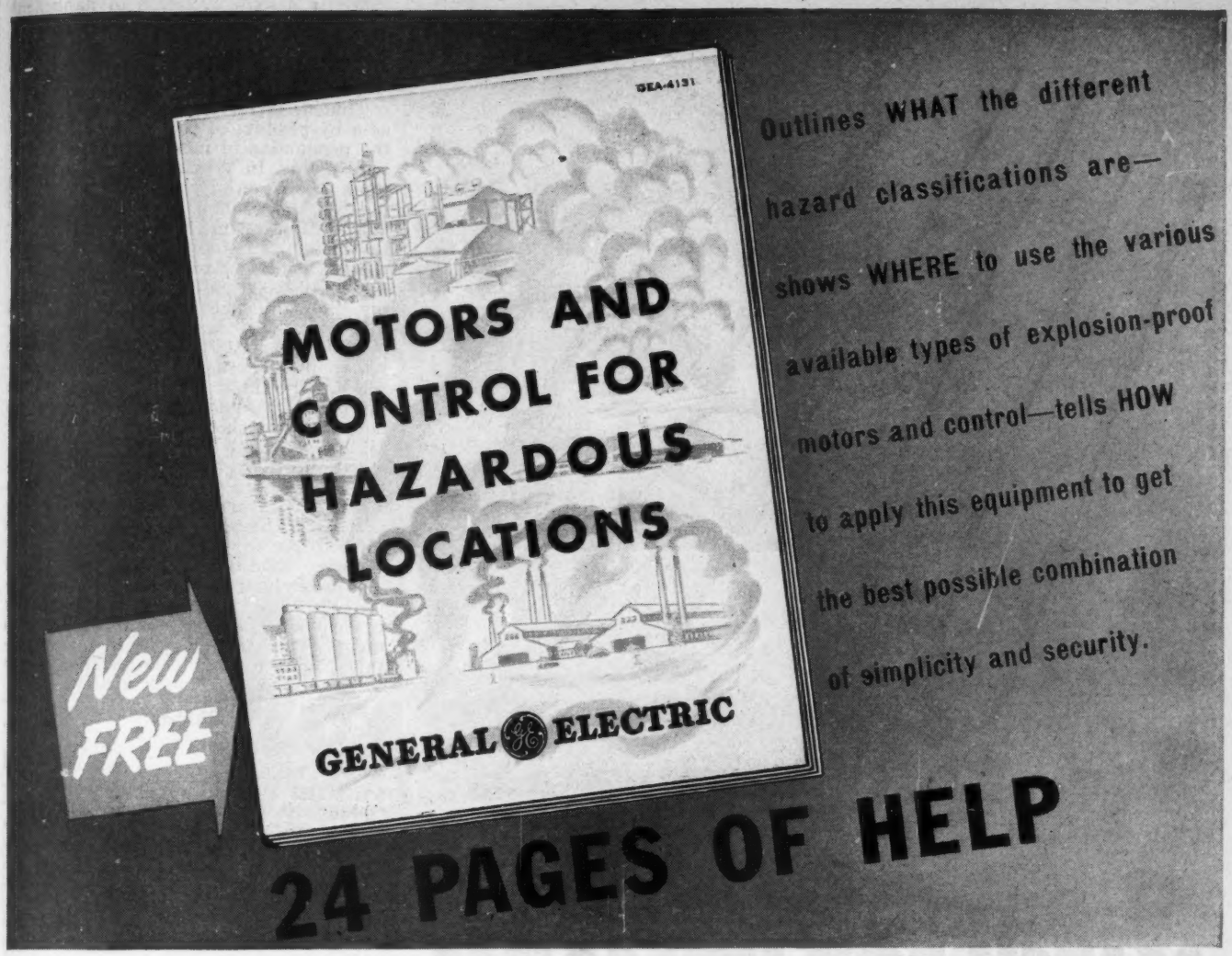
Research and invention in the petroleum industry have developed new and improved types of lubricants for a wide variety of uses. Highly refined oils are used in bearings of watches and precision instruments. Special high-pressure lubricants are available for machines where pressures may be many tons per square inch. Lubricating oils for high-speed diesel engines contain added detergents to wash tarry deposits from rings and cylinders, and to prolong operating periods. Airplane lubricants have been developed which are equally effective at tropic heat above 120° F. and at stratosphere cold more than 60° below zero, so that our fighter and bomber planes may function equally well in either extreme of temperature. The petroleum industry has a lubricant for every use.

The cracking process is the basis for the development of other processes because it furnishes large amounts of reactive hydrocarbons, both gaseous and liquid, for use in further syntheses. Cracked gases contain ethylene, propylene, and butylenes, which are absent in natural gas. For years these gases were used as fuel under boilers and stills. However, a few years ago a process for catalytic polymerization of these hydrocarbons was invented which produced superior gasoline of 80-82 octane. This was an advance in the conservation of crude oil since this type of gasoline, when added to a lower grade, increases the octane rating of the latter so that it burns with high efficiency in motors. The catalytic polymerization process operating on cracked gases under selective conditions yields isooctenes. Upon hydrogenation of these isooctenes, a gasoline of about 95 octane is produced which is one of the components of 100-octane gasoline for planes.

Alkylation

Extremely important processes in the war effort which called for great inventiveness in their development are concerned with the alkylation of isobutane with olefins to produce high-octane-rating aviation alkylate. Ipatieff and Pines, working in the laboratories of Universal Oil Products Company, first showed that paraffins could be alkylated with olefins, and invented a process for alkylating isobutane. Other research workers were stimulated to invent processes for effecting this reaction and as a result of their researches the sulfuric-acid and hydrogen-fluoride processes came into commercial use. Catalytic processes for isomerizing normal butane to increase the available isobutane have also been developed, as well as processes for isomerizing normal pentane to isopentane and normal hexane to isohexane. Cumene, a hydrocarbon used in aviation fuel, is made by alkylating benzene with propylene.

Another process of great import in the war is the manufacture of aromatic hydrocarbons by dehydrogenation and cyclization. Other processes effect the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An important section of this new book is devoted to suggestions for extending the "life expectancy" of explosion-proof motors and control. It emphasizes especially how to preserve the effectiveness of their explosion-proof features. It should prove a boon to anyone setting up a maintenance program.

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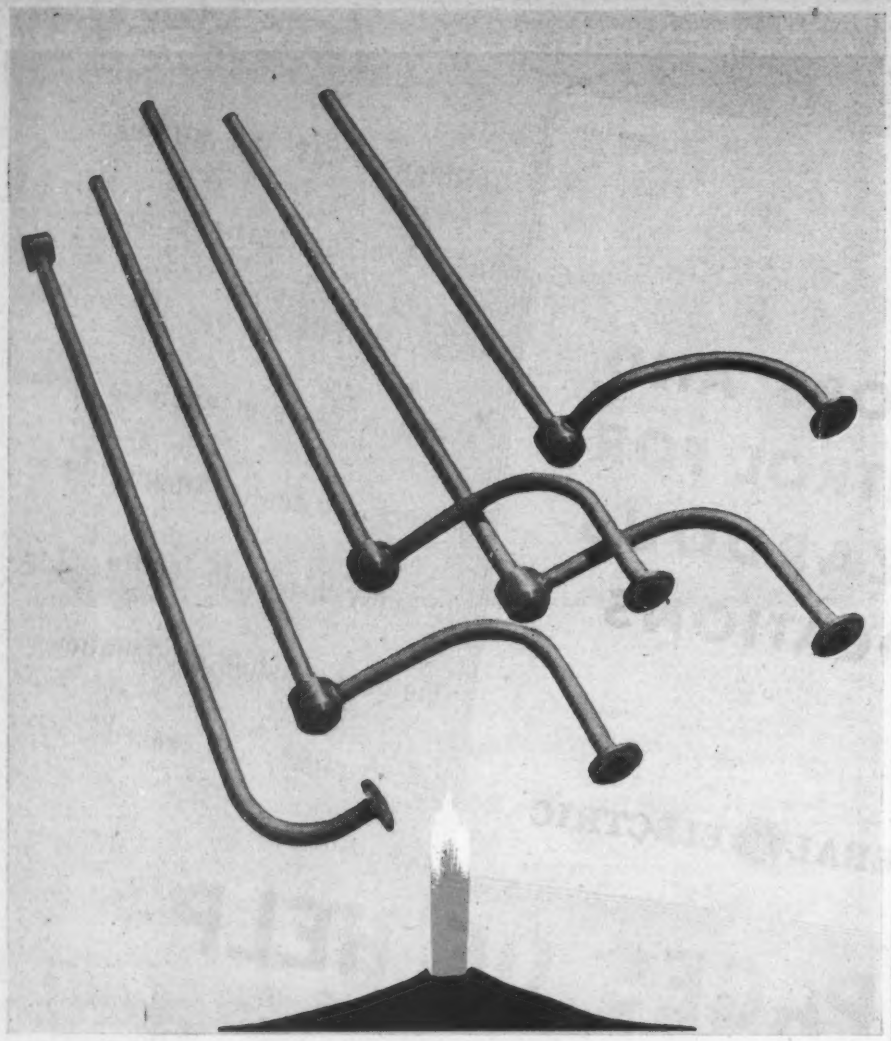

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catalytic dehydrogenation of naphthene hydrocarbons to produce aromatics, such as benzene and toluene.

Toluene from Petroleum

Toluene formerly was produced solely as a by-product of coal carbonization in the production of metallurgical coke for steel plants. In World War I, the maximum toluene production was at the rate of 15,000,000 gallons a year, and practically all of it came from coal carbonization plants. The toluene production from coal in World War II is at the rate of over 25,000,000 gallons a year. According to published reports, toluene requirements now approximate from 250,000,000 to 300,000,000 gallons a year which produce 3,000,000,000 pounds of TNT. The bulk of this comes from petroleum, through the inventiveness of chemists and chemical engineers in the oil industry. If it were not for these outstanding inventions for the manufacture of toluene, there would be a shortage in TNT production. The amount of coal that would be required to produce from 250,000,000 to 300,000,000 gallons of toluene would be about 300,000,000 tons. The oil industry has been so successful in producing toluene that there is a present excess over explosive requirements, which is being added to aviation fuel blends to augment the supply and to raise their anti-knock quality.

Rubber

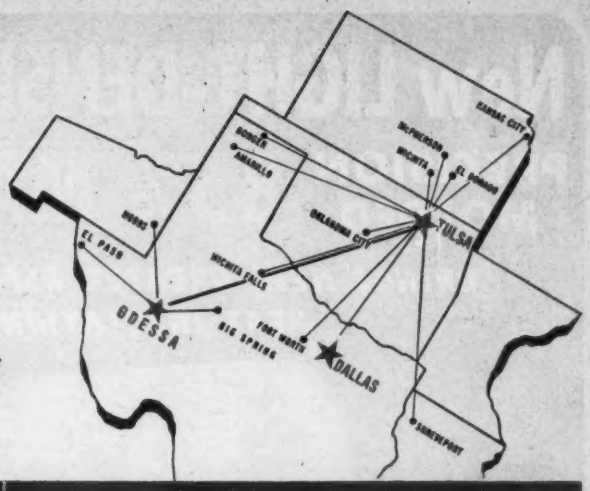
A special field of invention is concerned with the development of processes and catalysts for dehydrogenating butane to butylenes or to butadiene. These processes have largely assisted in the growth of the rubber industry in the United States. Copolymerization of butadiene and styrene gives Buna-S rubber for tires, and the polymerization of isobutylene and a small amount of isoprene produced from petroleum gives butyl rubber. This last material is especially good for inner tubes. Tests have shown that in a tire at 40 pounds pressure, the loss is only 0.08 pounds a week, or 4 pounds pressure in a year. When completed and operated at full capacity the plants for producing butadiene from petroleum hydrocarbons will supply from one half to two thirds of synthetic rubber requirements. As a result of the efforts of numerous inventors and researchers in the United States, the processes for the manufacture of synthetic rubber were available in this country when the war started.

Increased supplies of distillates from crude oil and cracking processes have promoted the use of these oils for household-heating purposes; consequently, many new inventions of oil burners and furnaces have resulted. The increased supplies of heavier residual oils have also stimulated the invention of improved types of burners and furnaces for use under boilers and heating units of industrial plants. Inventions in this field have greatly aided in the conservation of oil resources.

Metallurgical Advances

It is difficult to overestimate the influence that the cracking process and auxiliary processes have exerted on building new and enlarging old industries. A branch of metallurgy has developed a large number of special alloy steels to withstand the effects of high temperatures employed in cracking. An outstanding development in this line is the class of nickel-chromium alloys,

Vinson SUPPLY COMPANY



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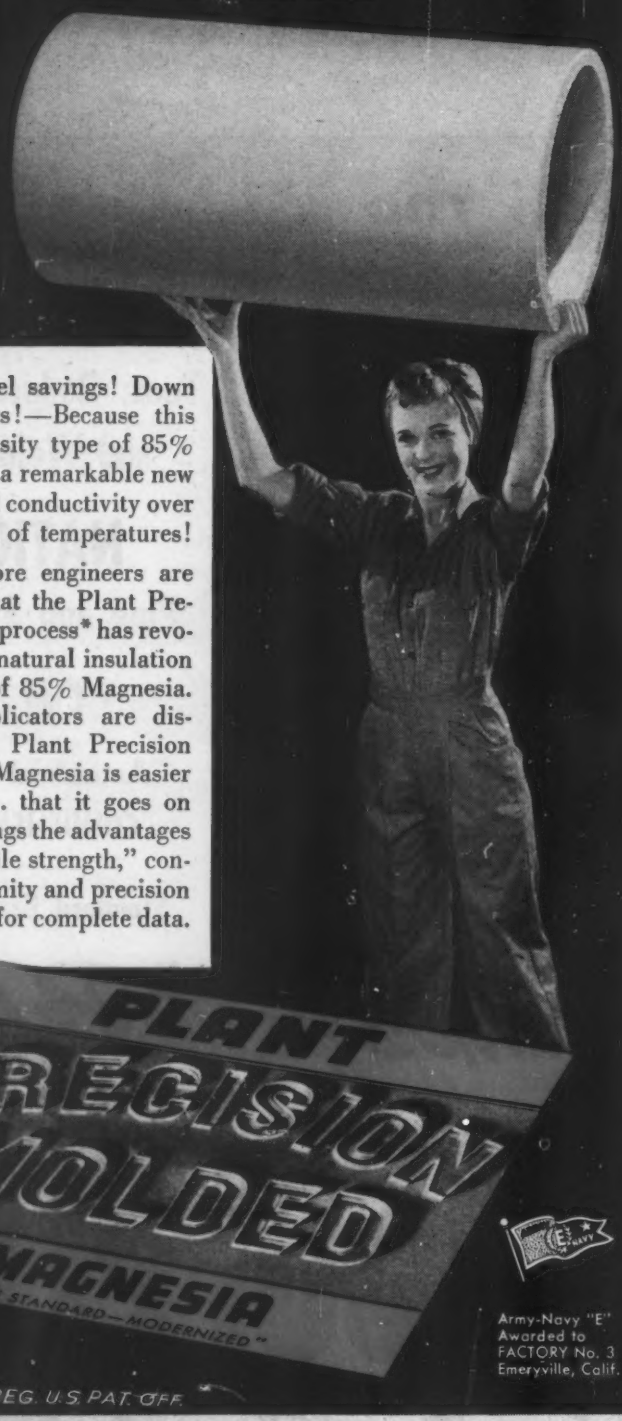

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which are resistant, not only to heat, but also to the corrosive effects of sulfur and oxygen. In order to control and regulate cracking and auxiliary processes in respect to temperature, pressure, and rates of flow, a large industry for the manufacture of special instruments has been built up. The availability of reactive olefins, aromatics, and isoparaffins from cracking and allied refining processes has furnished bases for the manufacture of an ever-increasing line of chemical derivatives. The manufacture of synthetic rubber has been aided by the production of butadiene and styrene, and the plastics industry has been furnished many raw materials. The increased supplies of gasoline from cracking have promoted the automobile and airplane industry, and lessened the cost of both the manufacture and the operation of automobiles, trucks, busses, and planes. Large manufacturing enterprises stem from the automotive industry. Metals, fabrics, plastics, glass, electrical equipment, paints and enamels, and many other essentials have undergone increases in production to supply materials used in the manufacture of automobiles. Our increased warplane output has also furthered the development of new processes for making radios, cameras, bomb-sights, stabilizers, gyroscopes, and a multitude of other instruments essential in combat flying and precision bombing. Without gasoline, many of these industries would never have come into being. The increase in industrial employment directly traceable to the development of cracking and allied processes is thus extremely large.

Spur of War

Under the spur of war necessity, the best scientific and technical minds in the industry sought and found the solution of various problems in many processes which have the standing and dignity of invention. Missing links were forged and processes which would have waited years for commercial development in the normal course were designed and put into successful operation almost overnight. To understand the importance of these processes it is only necessary to know that almost every drop of 100-plus-octane gasoline that gives our flyers dominance in the air, is primarily produced by catalytic processes.

American inventions in aviation gasoline processes gave the R.A.F. 100-octane fuel, and tactical superiority over the Luftwaffe in 1940. This made possible the winning of the Battle of Britain, and turned the course of history. Without our research and developments in motor-fuel manufacture, fostered by the patent system, the United Nations might well have lost this war.

Just as oil finding is an unusually adventurous and costly project, the uncertainties of research and development in manufacturing processes have been great. There are also many dry holes in oil-refining research. A large number of inventions may be made and a great deal of research conducted in attempting to develop a new and useful process before producing anything commercially successful. Great as the achievements have been in development of both thermal and catalytic cracking processes, it is well to remember that over $500,000,000 was spent in research and development projects, and in plants which were commercial failures. It may be asked what impelled the inventors in these fields to drive on in the face of such dis-

couragement. The driving force was the incentive offered by our patent system. Certainly, rewards should be forthcoming to successful processes based on invention after the expenditure of time, energy, and capital.

Development of Inventions

There is an idea in circulation that inventions result from quick flashes of thought which may be considered as either sudden inspirations, or more or less fortuitous guesswork. Nothing could be further from the truth. Worthwhile inventions are produced by the same "blood, sweat and tears" made famous by the eminent Prime Minister of Great Britain.

Patented inventions benefit the consuming public, industry, and research. The inventor has full rights to his invention during a 17-year period. After this the patent becomes public property and may be used by any citizen. When a patent issues, industry is informed of the new development embodied in the patent and often recognizes a commercial trend wherein patentable improvements are possible. Whole new industries have been developed based on patented processes in oil refining. Research is fostered in that its findings can be protected, and publication of results can be more complete and widespread, thus cutting down duplication of work and furnishing a basis for further study and experimentation. Anyone can purchase a copy of a patent for 10 cents. The patent specification gives complete and detailed information as to the nature of the invention. Without patent protection, research would be driven underground and secret processes would develop. Chaos would reign in business and industry, and piracy of processes and methods would become common practice. Systems of espionage would develop for getting information on new processes and products, so that they could be used by competitors without consideration of inventors' rights. Manufacturing concerns could easily be put out of business by such thefts. Under such conditions it is questionable whether small businesses could survive. Those employed in industries would be enjoined from normal discussion of their work either inside or outside of their company, and cooperative research efforts would be frustrated. This would result in slowing up invention, if not in eliminating the United States from world leadership in industry, which it has held for many years under the patent system. One invention always promotes others, and inventors react catalytically on one another.

Patent Ownership

The ownership of patents is the inducement for capital to invest in the promotion of new processes and products. Without patent protection, companies could not afford to take the risks inherent in research work. Neither would they feel justified in financing research foundations at universities where much work of a fundamental character is carried out if they could not be assured of rights in developments. Licensing of patented processes in the oil industry is widespread, and small and large refiners use them. Thus the use of new processes becomes diffused more widely among large and small companies. The small refiner is able to operate patented processes which he would have no chance to develop by his own research, and so is able to compete with large companies and, often, to produce products at a lower price.

Without the active exploring faculty of the American inventor, these developments would not have been possible.

What applies to the oil industry also applies to other industries. Industrial processes and relationships are extremely involved and frequently influence one another. The inventions of one industry stimulate inventors in apparently unrelated fields. Inventions have cut down the amount of physical labor necessary in manufacturing processes, without promoting unemployment. In fact, inventions have increased employment. The products of inventions, such as the automobile and the airplane, also save labor while providing more jobs. Inventions bring about competition which keeps industry young by constantly producing new processes and materials. Inventions mean low-cost products.

It is difficult to visualize the kind of oil industry we would have today without the inventor and the United States patent system. So little progress would have been made that in comparison it would seem like a throwback to the beginnings of the industry. Our whole social and economic system would be on a far lower plane if we did not have our patent system. The lack of petroleum products for automobiles, diesel engines, railways, marine transportation, airplanes, industrial plants, and military machines would be disastrous to our way of life. However, we have been safeguarded through our collective inventive genius and our patent system, so that our oil supplies are ample for every essential need of the present and the future.

The postwar period will see research and inventions developing at a tempo far greater than before World War II. All civilized countries are aroused to the importance of research, inventions, and patents; not alone in the war effort but in the peacetime to come.

Standard Oil Development Company Sponsors Research Forum

In celebration of its twenty-fifth anniversary Standard Oil Development Company sponsored a silver anniversary forum in the Waldorf-Astoria Hotel, New York, October 5 on "The Future of Industrial Research." The morning session was on the theme:

"What Should Be the Guiding Principle and Objectives for the Commercial Programs of Industrial Research and Development Organizations?"

Charles F. Kettering, general manager of the research laboratories of General Motors Corporation, presided. Subjects and speakers were: "The Physicists' Viewpoint," Dr. Frank B. Jewett, vice president, American Telephone and Telegraph Company; "The Chemist's Viewpoint," Thomas Midgley, Jr., president, American Chemical Society; "The View of Industrial Management," Harry L. Derby, president, American Cyanamid and Chemical Corporation.

Discussion followed each paper and the morning session was closed by a summary by the chairman.

The luncheon program consisted of remarks by Colonel Bradley Dewey, president of Dewey & Almy, Chemical Company, Boston, former rubber director of the War Production Board.

The theme for the afternoon session, over which Warren K. Lewis, professor of chemical engineering at Massachusetts Institute of Technology, presided, was:

"How Can Small Business Serve Itself and Be Served by Industrial Research and Development?" Subjects and speakers for this session were: "Research by the Business Itself," Edwin H. Land, president, Polaroid Corporation; "Research by Trade Association and Cooperative Groups," Dr. Westbrook Steele, executive director of the Institute of Paper Chemistry; "Professional Research Organization," Dr. Earl P. Stevenson, Arthur D. Little, Inc.; "Research Foundations," Dr. Clyde E. Williams, director of Battelle Memorial Institute; "Research by Government," A. C. Fieldner, chief of the Fuels and Explosives Branch, United States Bureau of Mines.

The dinner was the occasion for remarks by Frank A. Howard, president of Standard Oil Development Company, and the address by Robert P. Patterson, Undersecretary of War; "What Place Should Industrial Research and Development Organizations Allocate to Future Work Directed Primarily Toward National Security Rather than Commercial Considerations?"

In sponsoring the forum the company offered this viewpoint:

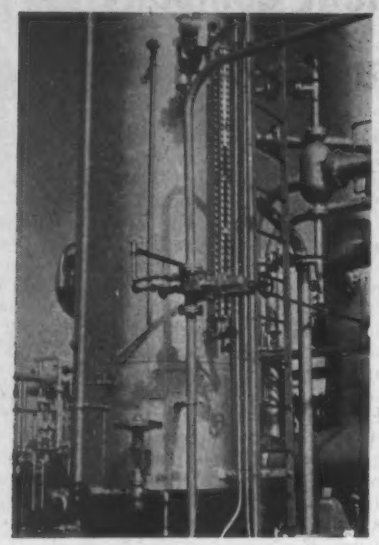
"Standard Oil Development Company believes that the most useful contribution it can make to commemoration of its twenty-fifth aniversary is the sponsoring of a forum for discussions which will aid in forecasting the probable future responsibilities of industrial research and development organizations of all kinds. Such discussions are of immediate and vital interest not only to those concerned with the government's part in and attitude toward research by industry and to those who report to the public on such questions."

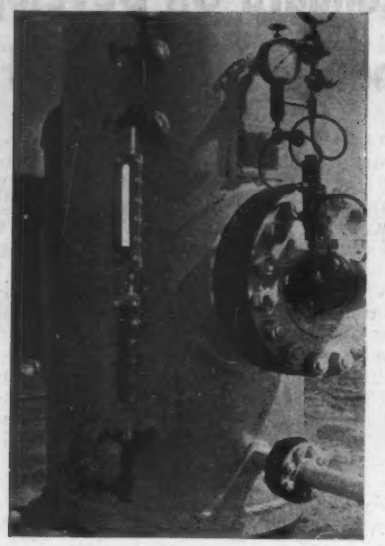
Wilson Says Refinery Reconversion to Be Speedy

Robert E. Wilson, president of Pan American Petroleum and Transport Company, said at New York September 20, that the American petroleum industry will require no more than 48 hours after it is released from war contracts to switch to capacity production of civilian products superior to those available before the war. He voiced this opinion before a meeting of the Empire State Petroleum Association and said further that unless Japan collapses suddenly, victory over Germany is not likely to result in any substantial decline in military requirements for petroleum for at least six months.

Samuel E. Eckert, vice president of Sun Oil Company, at the same session, predicted supply will be in excess of demand during the readjustment period that will occur after both Axis powers are defeated.

Eckert called on the industry to make postwar plans on the assumption that





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the temporary excess of supply will soon be absorbed by increasing demands for new products, which will add greatly to a resurgence of demand by motor cars, trucks, diesel locomotives, household burners, and other uses. This situation, he said, will lead the industry to its greatest success.

Wilson forecasted moderate relaxation in rationing at the end of the European phase that will offset any curtailment of military demand during the period required to defeat Japan. This means, he said, that the industry will be able to operate very much as at present except for some degree of relaxation of the current pressure for maximum refinery runs and maximum gasoline yields that are being obtained regardless of cost. Reduction in military demands for the first six months of all-out war in the Pacific, according to Wilson, might well average something like 300,000 barrels of high-octane gasoline daily, even after making allowance for the policing and rehabilitation of Europe.

Regarding the tanker situation he predicted that it would continue tight until all phases of the war are ended, and that it will represent the principal bottleneck in getting products to Pacific fronts.

Chemical Show-Conference At Chicago November 15-19

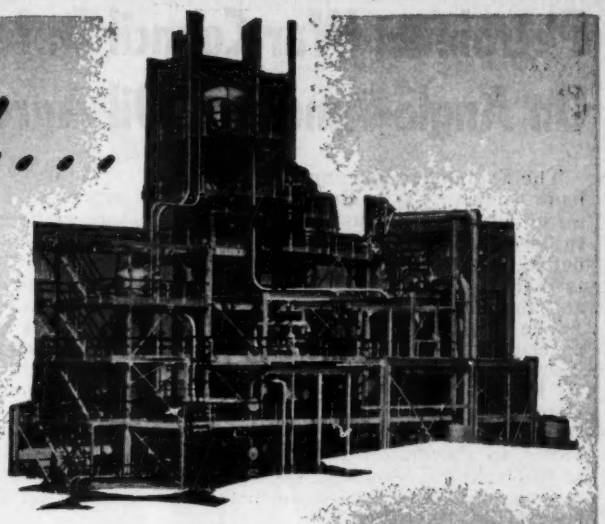
George Granger Brown, president of the American Institute of Chemical Engineers, will discuss "The Chemical Engineer in the Petroleum Industry," at the evening session November 16, during the third biennial National Chemical Exposition and National Industrial Chemical Conference to be held at the Coliseum, Chicago, November 15-19. J. K. Roberts, Standard Oil Company (Indiana), will be one of three speakers at the opening session, a luncheon, his subject being "New Research Delevopments in Industry." The other speakers on that subject are Roy C. Newton, Swift & Company, and E. H. Volwiler, Abbott Laboratories. J. Collyer, president of The B. F. Goodrich Company, will share the Thursday evening program with Brown, to speak on 'The Chemical Engineer in the Synthetic Rubber Industry." C. F. Kettering will be the speaker at a dinner meeting on November 17. Other speakers on the conference program will discuss metals and pharmaceuticals.

The show and conference is sponsored by the Chicago Section of the American Chemical Society. Exhibits have been arranged to fill the coliseum and its annex, and conferences will be held on the second floor of the annex. M. W. Hinson, manager of the exposition, has headquarters at 330 South Well Street, Chicago 6.

Much Oil Delivered in Waste Space of Cargo Ships

Transport of oil in double bottoms and fuel bunkers of cargo ships, a wartime innovation adopted two years ago, has permitted delivery of more than 1,250,000 tons of fuel to England alone, releasing equivalent space in tankers, it was announced by the War Shipping Administration. This year oil so delivered is expected to be over 15,000,000 tons. Most every merchant ship leaving the United States now carries excess bunkers and double bottoms loaded to capacity.

On the Land...



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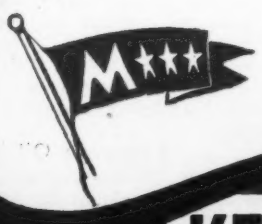

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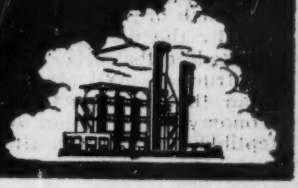


Petroleum War Council Defers Opinion On Anglo-American Oil Agreement

The September meeting of the Petroleum Industry War Council developed a number of problems which will have to be dealt with in the near future, and defined pitfalls which the industry will face through the remainder of the war and thereafter.

The pending Anglo-American oil agreement was the major subject of discussion, and was attacked by George A. Hill, Jr., president of Houston Oil Company of Texas. Hill disclosed that while 10 oil men were appointed advisors to the American representatives at the technical meetings last April only 3 were invited to participate in the discussions.

Speaking in the presence of Charles B. Rayner, oil adviser to the State Department, who headed the United States technical delegation, Hill attacked both the agreement itself and its adoption as a treaty rather than a convention. Hill recommended that PIWC go on record as opposing the agreement in its present form. The compact was defended by Rayner and by Deputy Petroleum Administrator Ralph K. Davies, who said it had nothing to do with price fixing or cartel arrangements. It was explained that agreement was not written with the idea of having it made a treaty, and that it was the President's idea to send it to the Senate for approval. After extensive discussion it appeared the consensus that members of the council do not disapprove the agreement if it is only an agreement, but refused to go on record in view of the short consideration it had been given. Senate consideration has been deferred until after the November election, and PIWC decided to refer the agreement to its oil policy committee for report and recommendation at the October meeting.

Vigorous opposition to the pact was expressed by a group of Texas operators gathered for a proration hearing at Austin September 19. Beauford Jester, chairman of the Texas Railroad Commission, presided at the get-together and was authorized to appoint a committee to further study the question and make proper representations to the Senate in its deliberations on consent to the pact. Grady Vaughn of Dallas was appointed chairman of this committee which is to have a membership of 15 or 20. The meeting expressed itself as condemning the pact because under it all United States oil activity "must be controlled by the federal government if world oil markets are to be divided."

A group of Houston operators headed by Glenn McCarthy met in that city to organize their opposition to the pact.

Ralph T. Zook, president of the Independent Petroleum Association of America, in his disapproval of the pact, expressed fear that foreign oil would flood American markets, and proposed "a permissive agreement dealing exclusively with oil in international trade, with power to make recommendations only, could keep such a situation from developing." He said the pact will come up for full discussion when the association's directors get together.

Gasoline Ration Talk

PIWC indicated its objection to continuance of gasoline rationing under any pretext after supplies of motor fuel become more plentiful, and raised the question of the propriety of the government selling oil and other surplus products at a profit. Objections were based upon a release by OPA which warned the public that gasoline rationing would be continued even if defeat of Germany resulted in a surplus of motor fuel, as a means of conserving automobiles and tires. The council reiterated its position that gasoline rationing should stand on its own feet, and if automobiles and tires are to be conserved, that is another problem. It was pointed out that if military demand for 80-octane gasoline declines because of less need in the Pacific war, the industry still must have an outlet for motor fuel if it is to provide the other war products. This applies particularly to smaller refiners who must sell all their products to continue operating.

Council members were alarmed by statements that government agencies propose to sell surplus products at a profit. Specifically they were concerned over a plan to package 250,000 gallons of lubricating oil purchased by the Army from a large company at 7 or 8 cents per gallon, to resell at the going jobber price of 18 to 20 cents, thus competing with the refiner who would have to buy it back to protect himself at a loss. It was pointed out that sales and deliveries to the government were made in large lots, without selling cost and for cash. The council proposes further study of this problem in view of more than 2 billion dollars worth of petroleum which is expected to be surplus at the end of the fighting.

PIWC's economics committee reported stocks of all oils will be at near-minimum level by next March should the European war continue through the winter. Sudden ending of that phase would mean a shift in demand and a different situation, with no information now available for predictions except that military gasoline requirements will decline substantially.

The report indicated demand for United States oil will be 5,437,000 barrels daily in the final quarter of this year, and 5,565,000 barrels in the first quarter of 1945. Supply will be 5,178,000 barrels in the final quarter, and 5,194,000 barrels in the first quarter next year, both including imports. Stocks will drop to 450,400,000 barrels by the end of the year, and 432,000,000 barrels by March 31, 1945.

The report pointed out that the Pacific theater already is consuming more than California can supply, but crude-oil production estimates there are more optimistic than heretofore, mounting to 892,000 barrels daily in the first quarter next year, and receipts from other districts by tank car will mount to 131,000 barrels daily. Adding natural gasoline, total supply on the Pacific Coast is expected to be 1,077,000 barrels daily in the first quarter of 1945, to meet a demand of 1,187,000 barrels, or a stock draft in that period of 110,000 barrels daily, such

PAW Survey Forecasts Big Construction Program

Refinery construction in the amount of $352,944,385 is the immediate need of the industry. The total is the result of an inquiry to the industry through the Petroleum Administration for War, which has sent its recommendation to the War Production Board with the suggestion that "immediate attention to this pent up demand would be appropriate."

The total consists of expenditure of $176,789,385 for domestic plant construction and $176,155,000 for foreign plants. The foreign total does not include areas still under enemy control.

In communicating the results of the questionnaire to the industry, Ralph K. Davies, Deputy Petroleum Administrator, wrote:

"Oil refinery operations have been increased by some 800,000 barrels of crude oil daily.

"This increase has been accomplished with a minimum of new construction and much of the overload has been handled by the prewar facilites."

He added that delay in authorizing new construction until after victory "would mean that the practical effect on the economy of the nation would be imperceptible until months after X day."

Interstate Oil Commission Opposes World Agreement

The Interstate Oil Compact Commission at the close of a three-day session at Oklahoma City October 7, recommended that the United States Senate refuse to ratify the Anglo-American oil agreement.

Attacks on the agreement were the subject of most of the speeches but speakers took advantage of the opportunity to condemn recent moves of the Federal Power Commission to investigate reserves of gas and waste in the course of its production. Observers interpreted it as another effort to obtain federal control of the oil industry, this time by a different federal bureau.

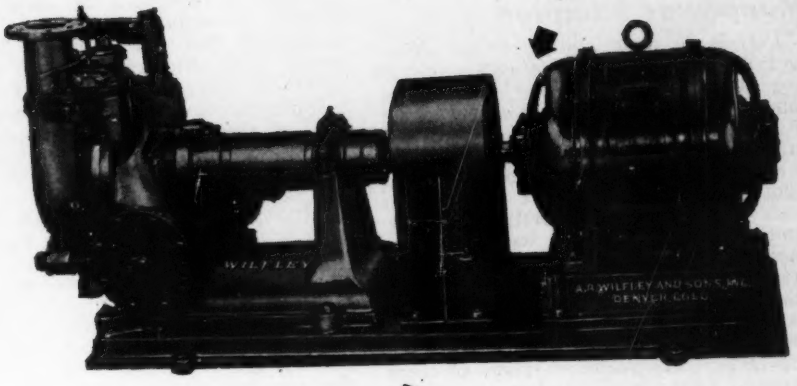
Ralph T. Zook, president of the Independent Petroleum Association of America, pointed to the fact that from the legal standpoint, such agreements as the Anglo-American pact are treaties which supersede state laws. Zook was one of the advisors who assisted in the conferences leading to the treaty, but his recommendations were not followed, he said. He urged that such an agreement should have dealt exclusively with the orderly offering of oil in international trade, and that any commission formed to carry out this agreement have advisory powers only.

Loss of market for American crude will result from the treaty as signed, Zook said. He fears a flood of foreign oil that will break prices here and eliminate further prospecting for domestic fields.

Pogue on Oil Pact

Joseph E. Pogue, vice president of the Chase National Bank of New York, said the long-range aim of the international oil agreement is to facilitate the orderly and efficient "development of the world's oil resources, avoiding on the one hand those repressive forces which make for an inadequate supply, and preventing on the other hand the hasty exploitation of rich deposits in such manner as to cause surpluses with their train of wasteful consumption and disinvestments."

High Efficiency



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draft to leave stocks at a satisfactory level of 69,600,000 barrels in that area.

May Be Too Much Fuel

Commenting upon currently high stocks of heavy fueloil, especially in the East, the committee saw that situation as only temporary but observed that a sudden termination of war in Europe and curtailment of industrial activities, particularly steel manufacture, would aggravate the situation.

PAW and WMC Differ on Manpower Situation

Petroleum Administration for War and War Manpower Commission heads are at variance over the question of labor supply in oil refineries following a statement released by WMC Chairman Paul V. McNutt that efforts of that bureau to channel labor into urgent war production have contributed materially to increased output of aviation gasoline, tetraethyl lead and synthetic rubber. Countering McNutt's statement that only one refinery (at Chicago) had assigned labor shortage as its reason for not meeting its allotment of aviation gasoline, PAW said that manpower problems, some of them serious, exist in a number of plants. There are labor shortages, it said, in two plants at Chicago, in several areas in Texas, some of which are critical, and in three plants at San Francisco. PAW officials have been working on these problems with WMC and are attempting to meet the labor needs of the plants which must be met if military requirements are to be filled, it was revealed.

McNutt's report showed that employment in aviation-gasoline plants increased by 2 percent during July to a total of 101,570 on August 1, and August production exceeded requirements by 10,000 barrels a day. July production of tetraethyl lead rose 2 percent above June, but total production for the year probably will fall 15,000,000 pounds short of requirements. Only one plant making tetraethyl lead had labor shortage, and it had an increase of 12.5 percent in personnel during the month. July production of synthetic rubber exceeded requirements by 10 percent, although employment in the plants declined 1.4 percent during the month.

'Small Business' Wants Price Hike, Depletion Allowance

Retention of the depletion allowance and a higher price were urged by a group of oil producers and well drillers appearing before the Patman small business subcommittee of the United States Congress at a hearing at Austin, Texas, September 20. Price increases for crude oil ranging from 35 cents to 63 cents per barrel were proposed by different operators, *some of whom contended that crude oil could be advanced 35 cents without affecting the refined-product price.* Also it was urged that refined prices have not been reduced although quality of products have been lowered in the war effort.

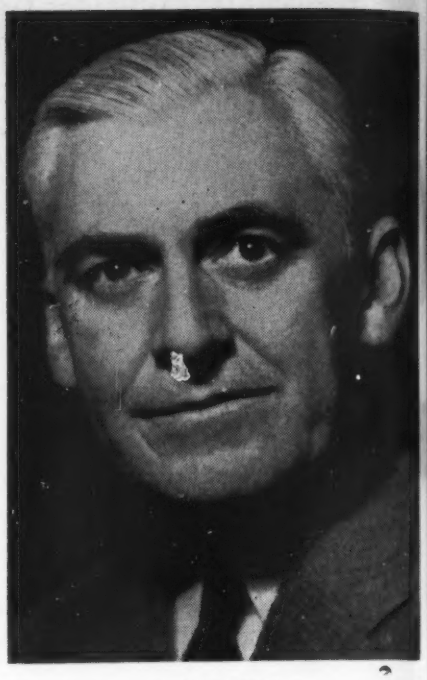
Congressman Wright Patman, chairman of the committee, suggested that now might be a good time to put in another request at Washington for a general price increase.

After the Austin hearing the committee returned to Washington and urged Stabilization Director Fred M. Vinson to make an immediate increase of 35 cents per barrel in the price of crude oil plus a stripper-well subsidy, *and subsidies for small refiners to avoid increases in retail prices.* Chairman Wright Patman of the committee was quoted as saying Vinson had promised to give the recommendation consideration. *Refiners for whom the subsidy is proposed were not asked for their views* in the matter, and in some quarters the opinion was expressed that if the crude oil price is raised it would be preferred that the raise apply also to products rather than further become enmeshed in subsidy-payment difficulties.

Robert P. Russell Heads Standard Oil Development

Robert P. Russell, who has been executive vice president of Standard Oil Development Company since 1937, was elected president following the resignation of Frank A. Howard, October 6. His resignation was made public at the twenty-fifth anniversary celebration of personnel of the company in Elizabeth, New Jersey, September 30.

For the present Howard will continue as director of Standard Oil Development Company and a vice president of Standard Oil Company (New Jersey). Next year he plans to re-enter the practice of law, in which he will serve the company as patent counsel.



R. P. RUSSELL

The new president has been with the organization since 1927 when he left an assistant professorship of chemical engineering at Massachusetts Institute of Technology to direct the newly organized Esso Laboratories at Baton Rouge. Since the outbreak of the war he has devoted much of his time to emergency technical work for the Office of Scientific Research and Development and for the National Defense Research Committee.

W. R. Carlisle has been elected a vice president of Standard Oil Development Company. He left private law practice to join the company in 1930 and for many years made headquarters in London, where he was active in organization of Esso Laboratories in 1937.

Howard, who is an engineer as well as an attorney, has been with the organization as its administrative head since its organization in 1919.

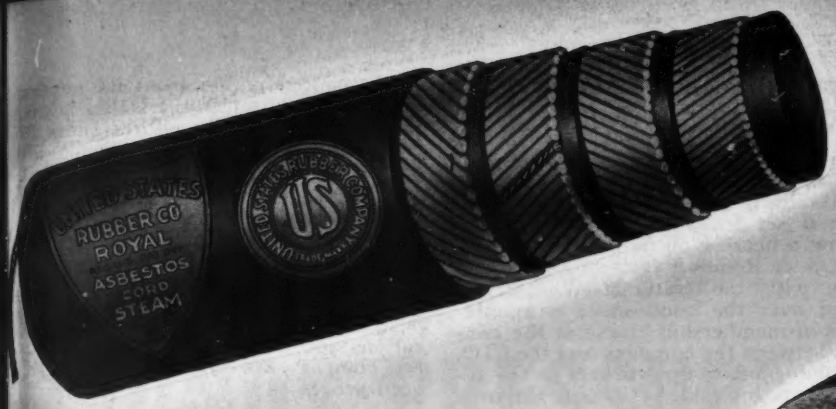
Standard Oil Development Company is the central research organization of

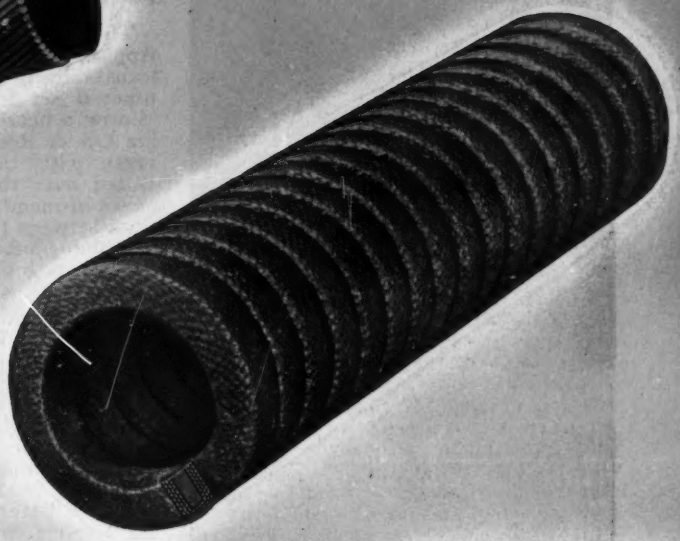
Crude Oil Run to Stills, Production of Refined Products, and Stocks for the Four-Week Period Ending September 30, 1944

(Figures, in thousands of barrels of 42 U. S. gallons each, based on reports of American Petroleum Institute. Production and stocks include reported totals plus estimated amounts to make these figures on a Bureau of Mines basis)

DISTRICT	Daily Refining Capacity		Crude Runs to Stills		Production				Stocks at Refineries, Terminals and in Pipe Lines				Crude Oil *	
	Potential Rate	Percent Reporting	Daily Average	Percent Operating	Gasoline*	Kerosine	Gasoil and Dist. Fuel Oil	Residual Fuel Oil	Finish and Unfinished Gasoline	Kerosine	Gasoil and Dist. Fuel Oil	Residual Fuel Oil	Daily Average Production	Stocks
East Coast, Texas Gulf, Louisiana Gulf, North Louisiana-Arkansas, and Inland Texas (Combined at request of PAW)	2,518	90.3	2,480	97.5	28,196	3,775	11,299	17,326	35,835	10,143	24,658	22,292	.....	.....
Appalachian District 1	130	83.9	103	79.7	1,171	262	327	322	2,204	303	506	277	.....	.....
Appalachian District 2	47	87.2	57	120.8	704	39	121	324	1,355	112	162	162	.....	.....
Indiana, Illinois, Kentucky	824	85.2	752	91.3	11,051	1,060	2,160	4,456	16,334	2,621	6,327	4,055	.....	.....
Oklahoma, Kansas, Missouri	418	80.2	375	89.7	5,765	525	1,556	1,893	6,814	833	2,037	1,574	.....	.....
Rocky Mountain District 1	13	17.0	11	84.6	132	12	29	117	56	10	13	29	.....	.....
Rocky Mountain District 2	141	58.3	111	78.9	1,445	53	346	769	1,524	104	403	669	.....	.....
California	817	89.9	773	94.6	8,165	191	2,411	10,478	13,906	457	11,223	35,168	.....	.....
Total U. S. September 30, 1944	4,908	87.2	4,638	94.5	56,629	5,825	18,249	35,685	78,028	14,583	45,329	64,226	4,735	221,490†
Total U. S. September 2, 1944	4,908	87.2	4,592	93.6	.....	.....	.....	.....	79,921	13,275	41,964	59,876	.....	223,482‡
Total U. S. October 2, 1943	.....	.....	4,204	.....	.....	.....	.....	.....	69,260	10,903	39,806	66,827	.....	233,013‡

* Includes natural gasoline blended at refineries. † Bureau of Mines, September 23, 1944. ‡ Bureau of Mines, September 2, 1944 and September 25, 1943.





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When the call goes out for hose or packings, it's usually a case of "Get it here yesterday!"

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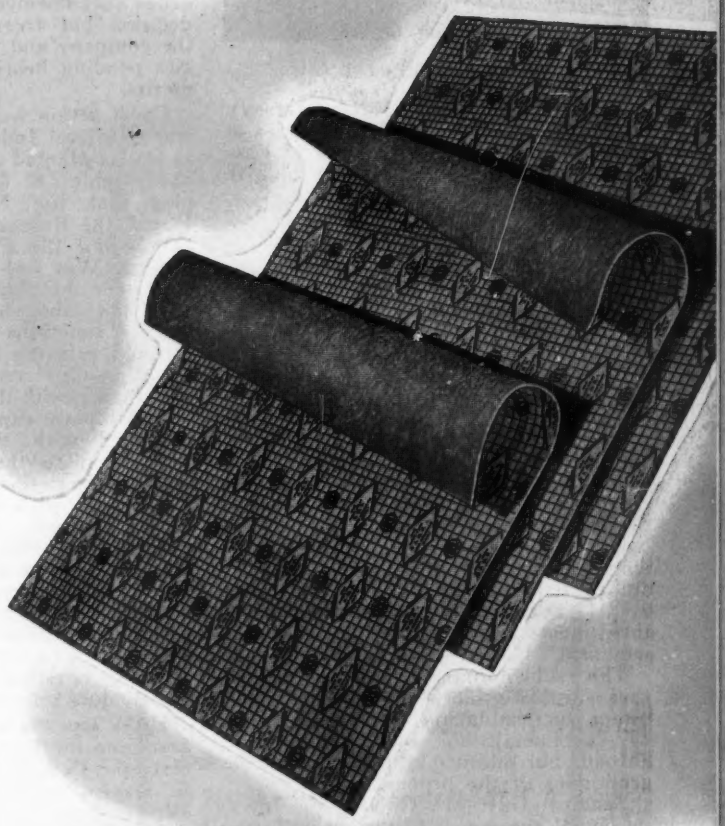
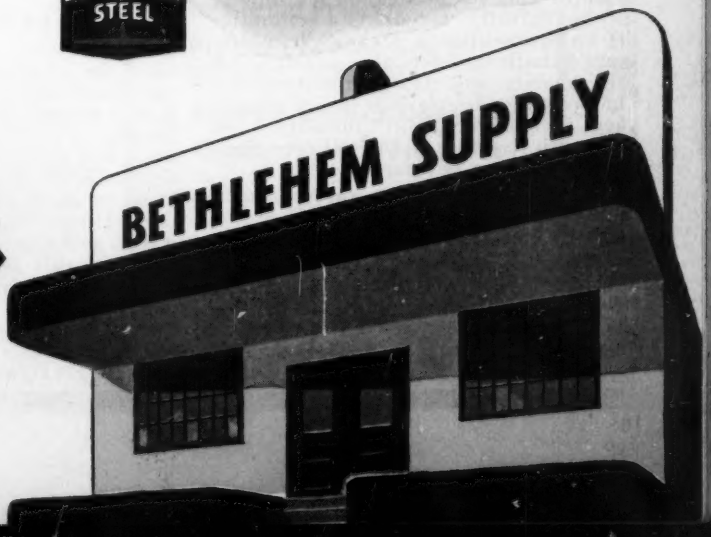
Your local Bethlehem representative is a trained specialist who really *knows* hose and packings—and the work they're built for. There's nothing hit-or-miss about it—nothing left to chance. Why not call him in on your maintenance jobs? He'll talk your language.



BETHLEHEM STEEL



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FRANK A. HOWARD

Standard Oil Company (New Jersey). In addition to the Esso Laboratories at Bayway it coordinates the work of Esso Laboratories at Baton Rouge and in London.

Grain-Alcohol Rubber Urged by Congressmen

Maintenance of production of synthetic rubber from grain alcohol despite its higher cost was recommended September 19 in a report of an agricultural subcommittee investigating expanded use of farm products. It pointed out the government has invested $150,000,000 in plants for production of rubber ingredients from alcohol, more millions in grain-alcohol distilleries, and stands committed to purchase $2,000,000 worth of grain in the next few years. On this basis it was contended grain rubber would cost less than petroleum rubber, and probably less than the natural product. If their proposal is not adopted, investments in the plants will be lost, it was said.

The subcommittee maintained also that surplus grain should be used for motor fuel, adducing testimony of use of gasoline-alcohol blends here and abroad, but admitting doubt as to the economics of the proposal.

Senator Guy M. Gillette of Iowa, perennial antagonist of the oil industry, has accused the oil industry of diverting gasoline ingredients to the rubber program as a means of stealing it from the alcohol industry. He wants a committee set up to investigate. Meanwhile, petroleum butadiene plants are operating below capacity, and alcohol distilleries are chafing under regulations which require them to make alcohol for industry when they wish to return to their normal business of making beverage alcohol.

Los Angeles AIME Will Have Synthetic Oil Paper

H. C. Miller, United States Bureau of Mines engineer, will discuss "Bureau of Mines Research on Liquid Fuels" before the Petroleum Division of the American Institute of Mining and Metallurgical Engineers, meeting at the Ambassador Hotel in Los Angeles on October 20.

Humble Takes Labor Board To Court on CIO Ruling

The United States Circuit Court of Appeals for the Fifth District (New Orleans) sitting at Atlanta, Georgia, October 3 set for November 6, at Fort Worth, a hearing on its merits of Humble Oil & Refining Company's controversy with the National War Labor Board over the question of a maintenance-of-membership clause in the contract between the company and the CIO, bargaining union for workers in the refinery at Ingleside (Corpus Christi), Texas.

The company went into federal district court at Dallas and secured an injunction against federal agents seizing the plant. This injunction was suspended by the circuit court at New Orleans on the plea of government attorneys that seizure of the plant was not impending nor contemplated. The hearing at Atlanta was on this supension of injunction, the latter action being upheld by the latest ruling. It was said that this order does not overrule the Dallas court decision but freezes relations between the company and the government agencies pending hearing of the case on its merits.

Court action was started September 7 when Federal Judge William H. Atwell at Dallas granted a temporary injunction on Humble Oil & Refining Company's plea that the National War Labor Board, the Bureau of Economic Stabilization and the Petroleum Administration for War had conspired together to take over the plant to force compliance with the labor board order, and had applied sanctions against the company through refusing applications for wage increases for employes, giving noncompliance with the order as the reason. The company explained that it had not complied with the order because it would violate the Wagner Act as it would discriminate against employes who might wish to withdraw from the union, and only 340 of its 14,000 employes were CIO members; that there was no labor trouble at the plant, and that inclusion of the maintenance clause might hinder rather than accelerate war production. [The company's contract with CIO, previously approved by WLB's regional office without the clause, does not expire until May, 1945].

PAW was made party to the suit (the first time the bureau has been so cited) through Deputy Administrator Ralph K. Davies having telephoned Harry C. Weiss, president of Humble Oil & Refining Company, to ask that the company comply with the labor board order, as PAW was being proposed as the operating agency in case the plant was seized, and PAW did not want the job. [PAW it seems had sidestepped taking over the plant of Hughes Tool Company at Houston when WLB suggested it as a proper agency for that operation because of that company's oil-tool business, and the fact that PAW had certified to WLB that work stoppage in the Hughes plant would affect oil production. Hughes was taken over by the Army which now is in charge. Controversy in this matter was the same as the Humble case in that it involves maintenance of membership. Hughes also has a suit pending before the circuit court at New Orleans]. Subsequently, George E. Dewey, PAW labor representative, went to Houston in an effort to dissuade Humble from its position. It was brought out in the Dallas hearing that PAW's friendly efforts suggested no alternative to full compliance with the order.

Government attorneys at Dallas questioned the court's jurisdiction over the defendants, denied that threats of seizure had been made, or that such seizure was pending. It was admitted, however, that unlawful sanctions had been imposed, and after filing of the suit applications for wage adjustments filed by the company for its employes had all been processed.

William Henry Davis Joins Sun Oil Staff

William Henry Davis has joined the engineering staff of the manufacturing department of Sun Oil Company, Philadelphia. He formerly was Eastern representative of Bechtel-McCone Corporation, with headquarters at Philadelphia.

Jennings Succeeds Brown As Socony-Vacuum Head

B. Brewster Jennings has been elected president and chairman of the executive committee of Socony-Vacuum Oil Company, succeeding John A. Brown who died September 9 while on vacation in Canada. Harold F. Sheets, a vice president, has been elected chairman of the board, a position vacant since 1935.

Wilbur F. Burt, chairman of the manufacturing committee since 1935, has been elected a vice president and a member of the executive committee.

Jennings, who is 46 years old, started with Standard Oil Company of New York as a clerk in the marine department 24 years ago. Serving later as purchasing agent and as manager of the real estate department, after the merger with Vacuum Oil Company in 1931, he was a director of a subsidiary, and became assistant to the president in 1936 and a director in 1937. Early in 1943, on leave, he had charge of government tanker operations, returning to

B. BREWSTER JENNINGS

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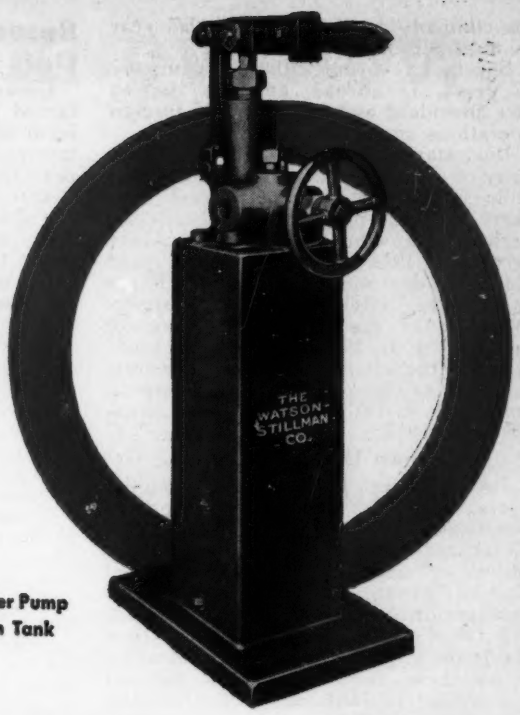
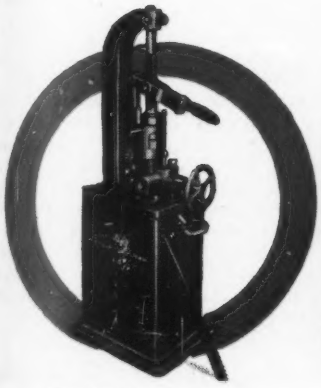
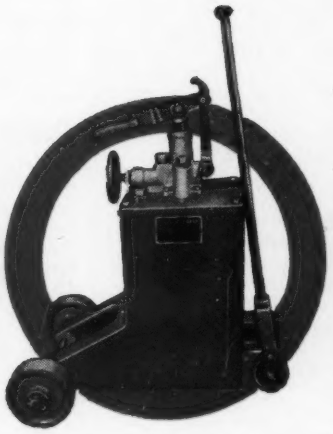


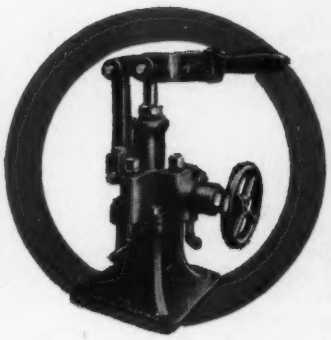
Single Plunger Pump on Medium Tank



Double Plunger Pump on Large Tank



Single Plunger Pump on Portable Truck.



Single Plunger Pump on Stand

Pump with Machine Steel Body, 30,000 lb. capacity

Watson-Stillman Hydraulic Hand Operated Pumps are self-contained units equipped with single or double plungers. These pumps are especially suitable for hydrostatic testing of pipe, valves, fittings, boilers and any equipment requiring an internal test. They are also used to operate hydraulic jacks, small machines and presses.

The single plunger type is available in pressure ranges from 1500 lbs. to 10000 lbs. per sq. in., and can be mounted on three different capacity tanks, 180, 400 and 1500 cu. in. Can also be furnished mounted on stand and portable truck.

The double plunger type has a large and a small concentric plunger. The small plunger is directly connected to the hand lever and produces the high pressure. The large plunger can be locked to the small one by a simple turn of a clutch and produces four times the volume at one quarter of the pressure that the small plunger delivers.

The double plunger pumps are available in pressures ranging from 1500 lbs. to 10000 lbs. per sq. in., and can be mounted on 400 cu. in. or 1500 cu. in. capacity tanks.

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WATSON-STILLMAN

his company on August 1 of this year as manager of transportation.

Sheets has been with the company 37 years, 17 abroad, and has been a vice president and in charge of foreign operations since 1932.

Burt started with Standard Oil Company of New York as a fireman on crude stills soon after graduation from Amherst in 1912, and was an assistant superintendent when he left for Army service in 1917. In 1919 he was made superintendent of the company's refinery at Brooklyn, later being general superintendent of the paint and cooperage department. In 1925 he was made manager of the claims and safety department, transferring to the manufacturing committee in 1927. He has been a director since 1935.

Brown Died in Canada

Brown's death followed an abdominal operation in Montreal. He was born in Pennsylvania 59 years ago, entered the oil business in California in 1911, shortly thereafter went to Mexico with Cecil Rhodes group and became assistant manager of Mexican properties of Standard Oil Company (New Jersey) when the latter acquired the Rhodes oil properties there. After nine years he was transferred to Netherlands East Indies, returning to California as vice president of General Petroleum Corporation in 1928, was made president in 1930, and moved to New York as chairman of the executive committee of Socony-Vacuum Oil Company in 1933, subsequently also being elected president.

Described by co-workers in national and industry affairs as a "war casualty," Brown was a member of the board and executive committee of API, chairman of the general committee of PAW District 1, member of PIWC from its inception, chairman of PIWC's national pool policy committee, and member of numerous other committees. He was one of 10 industry advisors of the United States group negotiating the Anglo-American oil pact last April.

E. W. Sinclair Dead

E. W. Sinclair, president of Sinclair Refining Company and chairman of Sinclair Oil Corporation, died at New York on September 21. He was born in West Virginia 70 years ago, and after attending school in Indiana and a period in the lumber business at St. Louis, entered the oil industry as agent for the Independence (Kansas) Gas Company in 1904. Later he was in the banking business, and went to Tulsa in 1913 as vice president and later president of Exchange National Bank (now National Bank of Tulsa). In 1921 he went to New York as vice president of Sinclair Consolidated Oil Corporation. He was a brother of Harry F. Sinclair, head of the Sinclair interests.

Beesemyer Heads Gilmore

Clarence S. Beesemyer has succeeded to the presidency of Gilmore Oil Company, Los Angeles, following resignation of E. B. Gilmore who has retired from active participation in the affairs of the company. Beesemyer joined the company in 1912 as a laborer and advanced through the sales department to become vice president and general manager in 1925. He is chairman of the distributing and marketing committee in PAW District 5, and is a member of the Petroleum Industry War Council.

Research Council Gets Army Praise

Coordinating Research Council, sustained jointly by the American Petroleum Institute and the Society of Automotive Engineers has been presented the Ordnance Distinguished Service Award in recognition of assistance given the Army in developing more efficient fuels and lubricants. Presentation was made by Major General G. M. Barnes at a banquet meeting in Washington. The award was accepted for the council by its president, B. B. Bachman, of The Autocar Company, and talks were made by Colonel H. W. Allen, past president of SAE and wartime advisor to the ordnance department, and by William R. Boyd, Jr., president of API.

General Barnes listed specific accomplishments from ordnance-industry cooperation and signalized by the award:

Development of an all-purpose gasoline suitable for storage under extreme climatic conditions, replacing seven gasolines lacking stability characteristics, suitable for use in all land and amphibian vehicles.

Development of a heavy-duty engine oil for all military vehicles, available in three viscosity grades instead of 10 and satisfactory for use under all conditions.

Replacement of seven grades of gear oil by three.

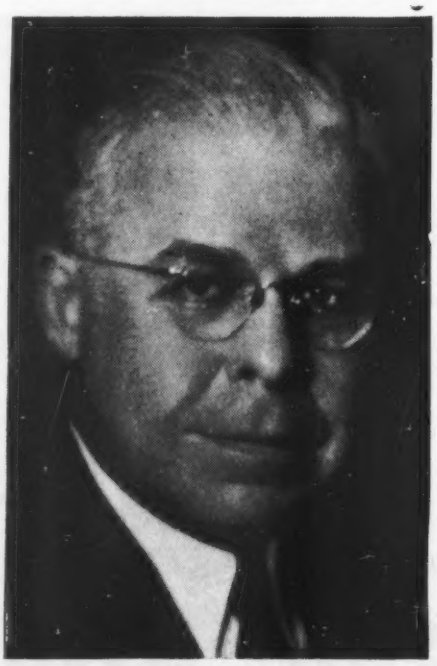
Greases, similarly reduced in number of grades, which operate at extremes of temperature.

Development of rust preventatives, which preserve both in storage and shipment around the world the armed forces' motorized equipment, engine parts, gun parts, and other material.

Analysis of enemy fuels and lubricants for the two-fold purpose of advising what captured supplies can be used in American vehicles and evaluating the enemy's oil position.

Chicago Chemists Honor Harper

Robert Brinton Harper, vice president of Peoples Gas Light and Coke Company, Chicago, is the 1944 recipient of the Honor Scroll award which is presented each year by the American Institute of Chemists to an outstanding member of the chemical profession. The award is made in recognition of distinguished service to the gas and allied industries. The scroll is to be presented by Dr. H. I. Jones, chairman of the Chicago chapter, at a testimonial dinner in the Morrison Hotel on October 6.



ROBERT BRINTON HARPER

Harper was graduated from Armour Institute of Technology in 1905, with a degree in chemical engineering, and joined Peoples Gas organization in June of the same year. He received the advanced degree of chemical engineer in 1909. Beginning as an assistant chemist in a five-man laboratory, of which he became the head within a year, he has steadily increased the scope and value of research and testing within his company. Today, he directs the operation of eight research and testing departments. He has pioneered in the development and standardization of methods for physical, chemical, utilization and plant testing. He has personally carried out a series of productive researches. He had played a leading part in formulating plans for a central testing laboratory for the gas industry which materialized in the American Gas Association Testing Laboratory, which he helped to direct from their inception to 1941.

Egloff Named

Dr. Gustav Egloff of Universal Oil Products Company has been elected a director of the Chicago Technical Societies Council, which represents 40 scientific and technical organizations in the Chicago area, with a membership of 15,000. He has also been elected a trustee of the Western Society of Engineers, which is one of the organizations represented in the Chicago Technical Societies Council.

Lubricating Grease Institute To Have Three-Day Meeting

The twelfth annual meeting of the National Lubricating Grease Institute in Chicago, October 23, 24 and 25, will offer two days of technical sessions, with the third day devoted to meetings of the technical committee and the business session of the organization.

Sessions will be held at Edgewater Beach hotel. Following registration the first day, the address of welcome will be given by William H. Oldachre, president of the institute. The technical papers for that day will be:

"Some Methods Used in the Practical Evaluation of Lubricating Greases," L. W. Sproule, Imperial Oil Company.

"Centralized Lubrication for Blast Furnaces," A. J. Jennings, The Farval Corporation.

"Report on the Activities of the Coordinating Research Council—War Advisory Committee, Grease Advisory Group," Walter C. Ainsley, Sinclair Refining Company.

"Greases for the Bureau of Ships," Lieutenant F. A. Christianson, United States Navy.

"A Machine for Performance Tests of Anti-Friction Bearing Greases," P. G. Exline and S. A. Flesher, Gulf Research & Development Company.

Technical subjects for the second day are:

"Torque Characteristics of Lubricating Greases," E. W. Adams, Standard Oil Company (Indiana).

"Separability Characteristics of

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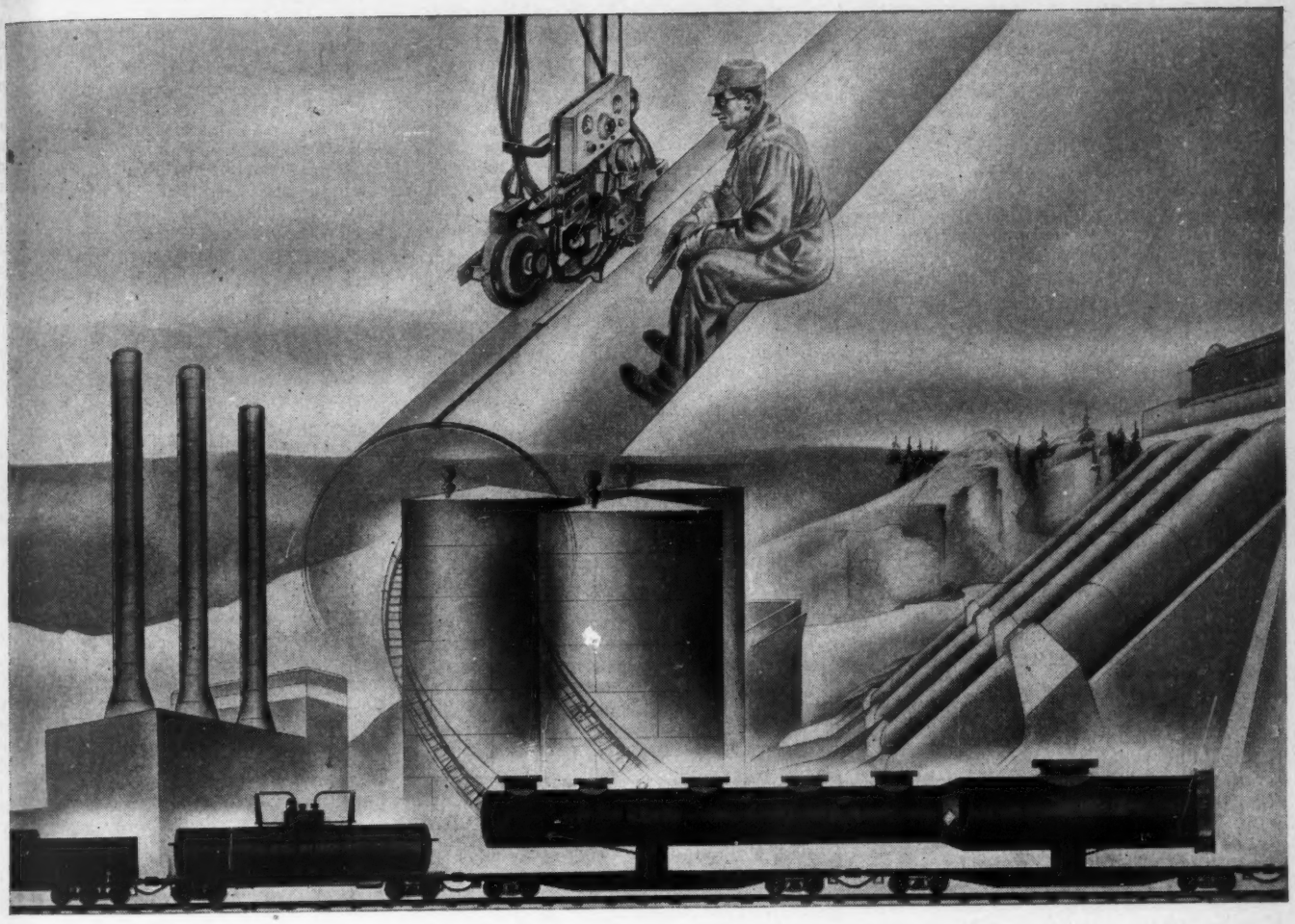

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Greases," T. G. Roehner and R. C. Robinson, Socony-Vacuum Oil Company.

"Notes on the Operation and Application of S. O. D. Pressure Viscometer," J. B. Patberg and J. C. Simmer, Standard Oil Development Company.

"Grease Lubrication of Aluminum Rolling Mills," Dr. E. M. Kipp, Aluminum Corporation of America.

"The Effect of Mineral Oil Pour Point on the Flow Characteristics of Lubricating Greases," C. W. Georgi and John F. O'Connell, Quaker State Oil Refining Corporation.

"Naval Gun Factory Performance Grease Tests," J. R. Reynolds, U. S. Naval Gun Factory.

Sessions of the technical committee will be open both morning and afternoon October 24. The business meeting, for members only, will take place at 3 o'clock that day.

Oil Firm Safety Directors Have Part in Meeting

Safety directors of several oil companies had parts in the program of the petroleum section of the Thirty-Third Annual National Safety Congress in Chicago, October 3-4-5.

Assigned to take part in the symposium on Weaving Accident Prevention into Operations, are the following: Discussion leader, C. L. Hightower, United Gas Pipe Line Company, Shreveport; "In Production and Manufacturing," C. A. Miller, The Texas Company; "Causing Key Supervisors to Carry the Ball," E. E. McPherson, superintendent of the Heath refinery, The Pure Oil Company, Newark, Ohio; "The Safety Supervisor's Position," P. E. Keegan, Shell Oil Company, New York; "Organization and Training Needed Now for Present Conditions and Postwar Changes," W. O. Wilson, Standard Oil Company (Indiana), Chicago; "Conservation of Manpower Through Off-the-Job Accident Prevention Activities," Roy S. Bonsib, Standard Oil Company (New Jersey).

Natural Gas Will Be Raw Material for Butadiene

Celanese Corporation of America has begun construction of a plant at Bishop, Texas, for processing natural gas into butadiene. The unit, which is similar to one already under construction, will be the first to use natural gas as the raw material for butadiene manufacture.

The unit now nearing completion will use natural gas as the raw material for finishing several chemicals, especially acetone, formaldehyde and several acids. Most of its output will be chemicals essential to the manufacture of the synthetic fabrics made by Celanese Corporation.

The butadiene unit will have capacity of 10,000 tons per year. It is being built by Gasoline Plant Construction Corporation.

Rubber Survey

The United States Tariff Commission plans early release of a report on rubber, both synthetic and natural. The report, said by officials to be the most important of 50 studies of major commodities, will cover the prewar position in international trade, costs and factors of costs of both synthesic and natural rubber, and probably will be projeced into the postwar era.

FPC Seeks "Constructive Public Policy" Relating to Natural Gas

A full investigation of the nation's natural gas resources has been ordered by the Federal Power Commission as a preliminary to recommending to Congress possible need for further legislation which, in its 1940 annual report, it suggested might be necessary.

Copies of the order have been sent to the governors and the regulatory and conservation commissions of all states, the Interstate Oil Compact Commission, natural gas companies, and coal, railroad, labor and other interested organizations asking statements of their views and suggestions, all such material to be filed by October 31.

The investigation will cover "the extent and probable life of natural gas reserves; present and prospective measures for preventing waste and prolonging the life of such reserves; present and probable future utilization of natural gas for domestic, commercial and industrial purposes; extent, character and results of competition of natural gas with other fuels; and such related matters as may be helpful in the administration of the natural gas act or in determining what additional legislation, if any, should be recommended."

The commission pointed out that there has been considerable agitation in some of the gas-producing states for curbs on the export of natural gas to areas where other energy resources are available. Representatives of coal, railroad, labor and other organizations interested in the production or transportation of competing fuels also have strongly urged the denial of requested certificates of public convenience and necessity or the imposition of restrictions which would substantially limit the uses for which natural gas might be sold.

The major competition betwen natural gas and other fuels has been found to come in the field of direct industrial sales from interstate pipe lines, the rates at which such sales are made not being subject to regulation under the natural gas act. At the same time, it has developed that large investments have been made in plant facilities designed for the utilization of natural gas in industrial processes, and that the conversion or replacement of such facilities to utilize other fuels would require large expenditures of money, time and materials and might effect substantial changes in the method of operation, cost of production and end products of many industrial plants.

In its announcement of the investigation, the commission gave assurance that it recognized fully the jurisdiction of the various state regulatory and conservation commissions regarding the producton, proration and distribution of natural gas in their respective states.

"It is not the commission's intention to trespass upon such authority in any manner whatsoever," it declared. "We seek the cooperation of the various state agencies, as well as other interested parties, so that every aspect of the public interest may be considered in an effort to solve the problems involved in our natural gas resources and uses.

"Extensive data and information relating to the problems involved in the conservation and utilization of natural gas have been obtained through proceedings under the natural gas act, but these data are not sufficiently complete for adequate consideration of the problems outlined in our order. It is necessary, for the purposes of this survey, to collect information on substantially all phases of the natural gas industry and, in order to avoid duplication, we plan to utilize the data and information already obtained by other federal agencies, as well as that in the hands of state agencies and others concerned with natural gas problems.

"We believe that such a cooperative survey will not only be productive of information needed for the administration of the natural gas act but will also develop constructive public policy in these important matters."

Bureau to Survey Sites For Synthetic Oil Plants

The United States Bureau of Mines has announced intention soon to send engineering parties into the field to survey more than 150 sites which have been proposed for synthetic-liquid-fuel laboratories and demonstration plants which will conduct a five-year program of research and development authorized by Congress several months ago. Sites have been proposed in nearly all coal-producing regions but other factors than raw material supply will be considered, it was indicated. Investigations have been made of potential oil yield of 14 coal beds and that work is continuing. Under the plan, coals from all sources will be given commercial-scale tests.

Three plants are contemplated, for coal, oil shale, and agricultural and forestry products. Each plant will be on a commercial scale and each will have a pilot plant and laboratory.

Probable site of the oil-shale demonstration plant is indicated by establishment of a headquarters office at Rifle, Colorado, by a party which is examining the 25-mile area between Rifle and DeBeque known as Piceance Creek Basin, which includes Naval Oil Shale Reserves Nos. 1 and 2. This area is favored by the Bureau because of predominant land ownership by the government.

Since 1936, the Bureau has conducted laboratory studies on coal hydrogenation in a small unit at the Central Experiment Station in Pittsburgh. Coals have been assayed to determine their oil yield and special catalysts have been developed which help increase the yield. About 30 gallons of gasoline are obtained from a ton of lignite and about 60 gallons from a ton of high-volatile bituminous coal. Influences of temperature, pressure, and other operating conditions have been investigated, and a low-pressure process has been developed which is particularly suited to the production of fuel oil. With a nucleus of trained engineers and a basic fund of technical information, the Bureau now is prepared to design and operate a large-scale hydrogenation demonstration plant.

The Bureau has been conducting laboratory investigations in the gas synthesis process for only slightly more than a year.

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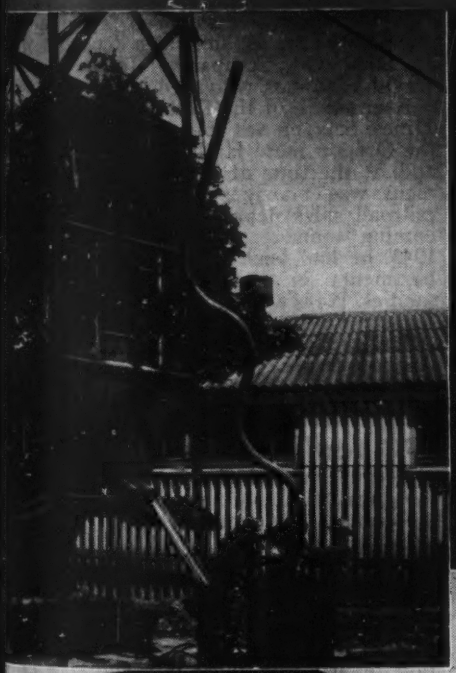

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Mines studied the extraction of oil from domestic oil shales. During this period, the Bureau mined and retorted approximately 6000 tons of oil shale and produced 3600 barrels of shale oil, which can be refined to yield products similar to those obtained from natural petroleum. The work demonstrated that large deposits of shale are available which will yield up to 45 gallons of oil per ton.

The Bureau of Mines has announced plans for an oil-shale research and development laboratory in connection with the petroleum experiment station at the University of Wyoming at Laramie. An architect is at work on plans for the required building which will include space for all facilities of the laboratory, including a small pilot plant, with a contemplated expenditure of $480,000.

Mines Bureau Establishes Synthetic Fuels Office

Establishment of an office of synthetic liquid fuels in the Bureau of Mines to carry out the five-year program of research and development to produce oil and gasoline from coal, shale and farm and forest products, was announced October 7 by the Interior Department.

Dr. W. C. Schroeder, with the Bureau since 1935 and assistant chief of the fuels and explosives branch for two years, has been appointed acting chief.

The developing of synthetic liquid fuels will be divided among four divisions; Research and development division, to be headed by Dr. Henry H. Storch; synthesis gas production division, headed by W. W. Odell, and a hydrogenation demonstration plant division and gas synthesis demonstration plant division for which chiefs have not yet been appointed. In addition, a new oil shale section has been set up in the Bureau's petroleum and natural gas division, under Albert J. Kraemer.

Dr. Storch has been with the Bureau as a physical chemist since 1928. Dr. Lester L. Hirst, who with Storch pioneered in the field of synthetic fuels at the Bureau's hydrogenation unit at Pittsburgh, will be assistant chief of the research and development division, and Dr. Joyce H. Crowell, research chemist with the National Aniline division of the Allied Chemical Company at Buffalo since 1934, has been named supervising engineer.

Odell, a former fuel research engineer in the Bureau, returns to take over the synthesis gas production division after extensive work in the gas industry and as technical adviser on butadiene, synthetic ammonia and petroleum research to the president of Lion Oil Refining Company at El Dorado, Arkansas. Louis L. Newman, who was with Semet-Solvay Engineering Corporation, Pennsylvania Public Utilities Commission, Mineral Industries Experiment Station at State College, Pennsylvania, and the WPB before joining the Bureau last year as a gas engineer, will be assistant chief of the division.

Kraemer, who has been with the bureau since 1923, will have H. P. Rue, heretofore supervising engineer of the petroleum experiment station at Laramie, Wyoming, in charge of the new oil shale research and development laboratory to be established on the campus of the University of Wyoming, and Boyd Guthrie, refinery engineer engaged in the Bureau's early shale experiments in 1927, as supervising engineer of the oil shale demonstration plant.

Universal Oil Products Company Offered to American Chemical Society

Acceptance of Universal Oil Products Company as a gift of its owners to the American Chemical Society is now under consideration by a committee. The offer was announced at the annual meeting of the society in New York September 14 when Thomas Midgley, president, said it had been accepted "in principle."

Donors are Phillips Petroleum Company, Shell Oil Company, Inc., Standard Oil Company of California, Standard Oil Company (Indiana), Standard Oil Company (New Jersey), and The Texas Company. They agreed to give the society full ownership of UOP with the provision that all income from the gift be "used by the society at its discretion for research in the fields of science relating to the oil industry."

President Midgley said the gift had a value of between $10,000,000 and $15,000,000 and that annual income from it will amount to $1,000,000. He expressed the opinion that in case of acceptance the UOP organization will be maintained as now set up and its research continued.

"Results of the research will be published and will be available to the public without payment. The donors will have no right to such results greater than those of the public at large."

Universal Oil Products Company had its beginning in the work of Carbon Petroleum Dubbs and its first contribution to the refining industry was the Dubbs thermal cracking process. Since then it has provided other contributions to refining, its outstanding processes being in polymerization and alkylation. It has about 100 refinery licensees.

Scotland Plans Expansion Of Its Shale Industry

The shale oil industry of Scotland is to be further expanded by development of a newly discovered deposit of shale on one of the larger islands of the Hebrides, off the northwest coast. According to the Scottish Council on Industry, plans have been completed for working and processing the rock.

Ohio's Cleveland Plant Announces Promotions

Changes in the operating personnel at the Cleveland refinery of The Standard Oil Company (Ohio) following appointment of C. H. Metz, Jr., as superintendent (PETROLEUM REFINER, August, 1944, page 140), included the following promotions:

Albert Schoenfeld was promoted from master mechanic to assistant superintendent of maintenance and construction, and C. D. Crawford from senior engineer, utilities, to assistant superintendent in charge of utilities. Both report to A. L. Peterson whose promotion to assistant superintendent of maintenance and construction recently was announced.

Oscar W. Walter was promoted from cracking-coil foreman to assistant process superintendent in charge of cracking. R. B. Preston was promoted from refinery foreman to assistant process superintendent in charge of distillation and treating. W. S. Diffenderfer was promoted to assistant superintendent in charge of the asphalt department.

W. H. Fletcher and Henry Jatzek were promoted to general foremen, and R. B. Kilgore and M. A. Pappas were appointed area engineers.

Nelson Salathe, metal inspector at Lima refinery, has been promoted to chief metal inspector at Cleveland, to replace George Goller who has been transferred to the home office general engineering division.

G. R. Thompson, H. G. Birggs and Saunders Kornhauser were named process foremen, and Frank Jedd foreman of the transportation equipment department, moving up from yard department foreman where he was replaced by G. E. Salis.

S. R. Bolles recently was promoted to superintendent of Sohio Petroleum Company's refinery at Latonia, Kentucky. He joined The Ohio Oil Company as cracking-coil foreman at Toledo in 1929.

Sawyer Heads Asphalt Department of Shell

J. W. Sawyer has been appointed manager of the asphalt sales department of Shell Oil Company. He succeeds David Waxman, who died in August.

A graduate of the Colorado School of Mines, Sawyer was for many years with the Oregon State Highway Department, and, at the time of his present appointment was manager of the company's railroad sales department. Prior to becoming manager of railroad sales in 1943, he had been with the asphalt departments in various managerial capacities. He is a member of the American Society of Testing Materials, the North Atlantic Highway Engineers, and the Asphalt Institute.

Regulations Proposed for LPG Tank Car Movement

Because of the shortage of pressure tank cars for handling liquefied petroleum gases, the transportation committee of the Liquefied Petroleum Gas Association has prepared a set of rules, which it is striving to put in practice. The statement and the suggested regulations are:

"The Office of Defense Transportation reports that there is a shortage of pressure cars for handling LP-gas products, and so that we as an industry, may attain the utmost use out of each car and thus avoid, as far as is possible, shortages of these cars to carry out needs, we have several suggestions that is important for every operator to carry out:

"1. Unload tank cars on arrival immediately, whether it be night or day.

"2. Notify the railroads of the availability of the empty car at the first possible moment.

"3. Follow up with the railroads on their pulling the empty car from the

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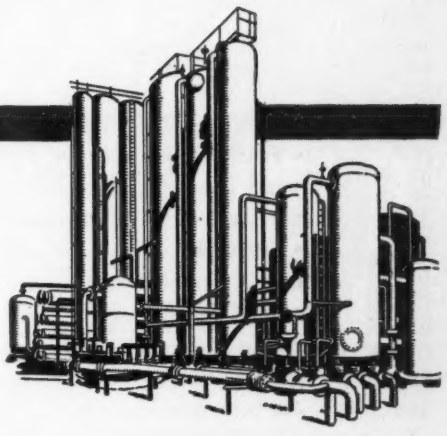

TO SPEED UP production of vital 100-octane-plus aviation fuel for America's aces, refiners developed alkylation processes which require temperatures from 80° to 90° below zero. Most of the refineries are located in warm climates. But even on the hottest summer days, outdoor pipe lines and towers must be operated at sub-zero cold.

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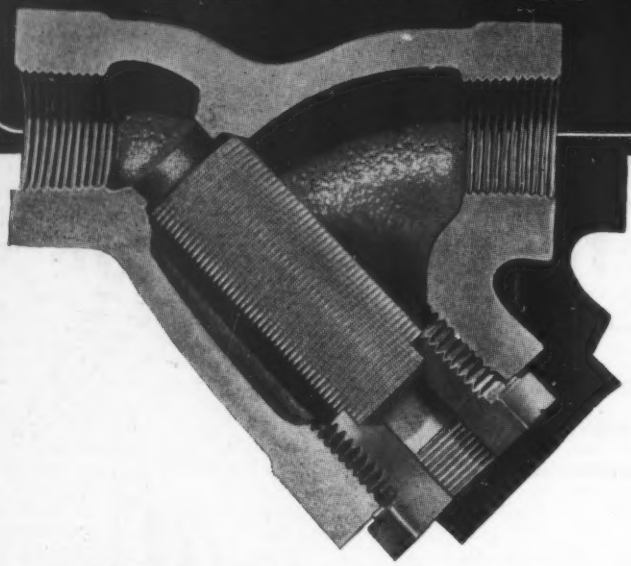

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siding so that it may start back to the originating point for another load.

"4. Use care in scheduling car arrivals so that there is ample storage space for unloading.

"5. In cases where vapor withdrawal delays the release of the car, it may be of greater value to release cars without recovering vapors in order to get the car moving again.

"The above information should be passed on to all in your organization who may assist in the movement of cars.

"Keep in mind that a day lost in a tank car movement may result in many customers running out of gas."

Holley Poe Cannot See Big Lines Carrying Gas

Conversion after the war of either the Big-Inch or the Little Big-Inch war emergency pipelines for transportation of natural gas from Southwestern fields to Eastern industrial centers was thought unlikely by E. Holley Poe, former executive vice president of the government's Petroleum Reserves Corporation. He couldn't see the conversion "based on status of the markets, problems of regulation and taxes."

He said the 20-inch line might be adapted to the movement of natural gas but "in my judgment it would be difficult to convert that line with sufficient pressure to deliver a quantity of gas to the East." He remarked that he had no opinion on the 24-inch line but added: "I can't see the necessity for it at this time nor for the near future."

Poe said that completion of the Tennessee Gas & Transmission Line project in October will probably alleviate part of the shortage of natural gas in the Appalachian area.

Opinion on Condensate and Distillate Taxes Delivered

Taxes on condensate and distillate shall be paid on three fifths of the gross value of all crude products where the same person produces and operates the plant, because the tax is a severance tax, according to an opinion prepared by Attorney General Grover Sellers of Texas. Many companies have heretofore paid on the value of the finished product.

If one person is the producer and another operates the plant, then the tax is on the value of the purchase price made by an "arms-length" contract.

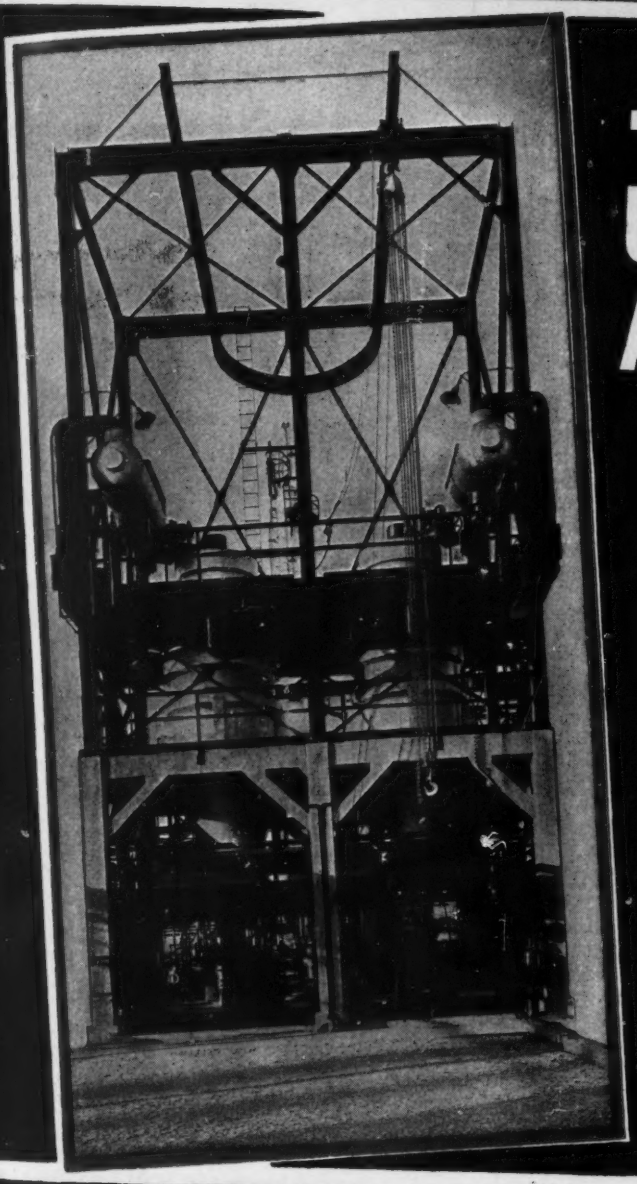
Texas Panhandle Plant

Phillips Petroleum Company is erecting a 50,000,000-foot daily gasoline plant in Hansford County, Texas Panhandle. Finished products will include 100-octane gasoline, and trial runs are slated for about December 1. The company's heretofore untapped natural gas reserve that centers upon Hansford-Sherman County line and the Oklahoma Panhandle border is currently receiving development to supply the plant, while the residue gas will be diverted to outbound transmission lines.

Jones Succeeds Brown In PAW District 1

W. Alton Jones, president of Cities Service Oil Company, has been appointed chairman of the general committee for PAW District 1, to succeed John A. Brown, deceased.

More Than 100 STRATCO CONTACTORS



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DIGEST OF UNITED STATES PATENTS

On Catalytic Aromatization and Cyclization

Compiled by HEINZ HEINEMANN

U.S.P. 2,313,346. Catalytic Conversion of Hydrocarbon Oils. W. Kaplan to Cities Service Oil Company.

Hydrocarbon distillate is heated under conditions which convert part of it into a mixture of cracked products low in aromatic hydrocarbons and containing approximately 50 percent of unsaturated hydrocarbons. A finely divided activated carbon catalyst is intimately mixed with the cracked products and passed through a reaction zone at 970-1050° F., keeping the mixture at this temperature for a considerable period so as to convert the products into a final product containing a relatively high percentage of aromatic hydrocarbons.

U.S.P. 2,317,683. Cyclization of Hydrocarbons. B. S. Greenfelder to Shell Development Company.

Aliphatic hydrocarbons having 6 to 12 C atoms per mol are aromatized by contacting them under cyclization conditions with a solid compound catalyst which consists of a metal selected from the left hand column of group VI (e.g., 2-30 percent of chromium as chromium oxide) supported on a major portion of an adsorptive alumina (such as bauxite) and promoted with from about 0.2-2 percent (based on the amount of metal in the catalyst) of platinum or palladium. The process is executed in the vapor phase at 1-10 atm. pressure and at 400-600° C. for contact times of 6 seconds to 2 minutes.

U.S.P. 2,321,006. Conversion of Non-Benzenoid Hydrocarbons to Aromatics. R. E. Burk and E. C. Hughes to The Standard Oil Company (Ohio).

Hydrocarbons are converted to aromatics by subjecting non-benzenoid hydrocarbons to the action of a contact mass characterized by 2-15 mol percent of copper oxide and 42.5-88.2 mol percent of gel type aluminum oxide which is coprecipitated with 8.5-49 mol percent of chromium oxide at 700-1250° F.

U.S.P. 2,322,863. Dehydroaromatization and Hydroforming. R. F. Marschner, L. Heard and A. G. Oblad to Standard Oil Company (Indiana).

The method of converting low-knock-rating charging stock into high-knock-rating motor fuel is claimed which comprises dehydro-aromatizing a low-knock-rating naphtha by contacting it with a catalyst selected from the class consisting of molybdenum, chromium, tungsten, uranium and vanadium oxides and mixtures thereof, supported on alumina at a pressure within the approximate range of 30-450 pounds per square inch at a temperature of about 875-1025° F. and at a space velocity which is sufficiently low to convert aliphatic hydrocarbons into cyclic aromatic hydrocarbons, whereby hydrogen is produced, admixing said hydrogen with additional charge stock in proportions of about 5-50 mols of hydrogen per mol of said charge stock and contacting said mixture with said catalyst under pressures of about 450-3000 pounds per square inch under such conditions that hydrogen is consumed and further quantities of high quality-motor fuel are produced.

U.S.P. 2,323,818. Preparation of Oxide Type Catalysts. E. C. Hughes to The Standard Oil Company (Ohio).

Chromium-aluminum oxide gel type catalysts for the aromatization of hydrocarbons are prepared by mixing solutions of salts consisting of a chromium salt and an aluminate, supplying acetate ions with an acid, and adjusting the pH to a numerical value of substantially 10 and precipitating. A sodium aluminate solution containing 0.25 mol NaOH per mol and a chromium acetate solution may be used.

U.S.P. 2,324,073. Treating Hydrocarbons. P. J. Gaylor and E. J. Mahler to Standard Oil Development Company.

A lower olefin, preferably with 3-4 C atoms per mol, may be made to undergo a direct cyclo-polymerization. The process involves use of a mixed catalyst comprising a volatile halide of the Friedel-Crafts type and a cyclizing metal or metal compound, e.g., compounds of molybdenum, tungsten, aluminum, vanadium, uranium, chromium, copper, nickel, etc. Combinations are preferable and the following have been found suitable: aluminum fluoride-nickel; molybdenum sulfide-copper; alumina-silica-tin oxide, etc. The volatile inorganic halide should be added to the olefin feed stock in amounts of 0.3-2 percent by weight of charge, prior to contacting the solid catalyst. Temperatures of 20-350° C. and pressures of 30-1000 pounds are used, depending on the type of cyclic compounds desired.

U.S.P. 2,324,165. Dehydroaromatization. E. T. Layng and R. F. Marschner to Standard Oil Company (Indiana) and The M. W. Kellogg Company.

Naphtha is dehydro-aromatized in a process which comprises fractionating the naphtha into a plurality of fractions of different boiling ranges and separately aromatizing each fraction by contacting it with an aromatization catalyst at a temperature of 875-1075° F. with a space velocity of about 0.04 to 10 volumes of liquid naphtha fraction per volume of catalyst space per hour under a pressure of about 30 to 450 pounds and in the presence of about 4-8 mols of hydrogen per mol of naphtha fraction. The severity of the contacting conditions is greater in the case of low-boiling than in the case of high-boiling fractions.

U.S.P. 2,325,839. Catalytic Treatment of Non-Benzenoid Hydrocarbons. R. E. Burk and E. C. Hughes to The Standard Oil Company (Ohio).

Hydrocarbons of non-benzenoid character are converted to aromatics with a preferred catalyst consisting of a gel-type oxide containing 18-30 mol percent of chromium oxide and 82-70 mol percent of aluminum oxide. In some instances small amounts of other oxides, such as copper, etc., may be present. The range of the chromia amount is critical, the high peak of action being at about 20 mol percent. Temperatures of 800-1200° F. are applicable and there is a special critical pressure range. The total gas pressure in the catalyst chamber should be controlled closely to between 40 and 180 pounds per square inch and preferably to about 100 pounds. Flow rates may be 0.1-10 liquid volumes per volume of catalyst per hour.

U.S.P. 2,329,672. Manufacture of Aromatic Products from Light Olefins. C. Weizmann.

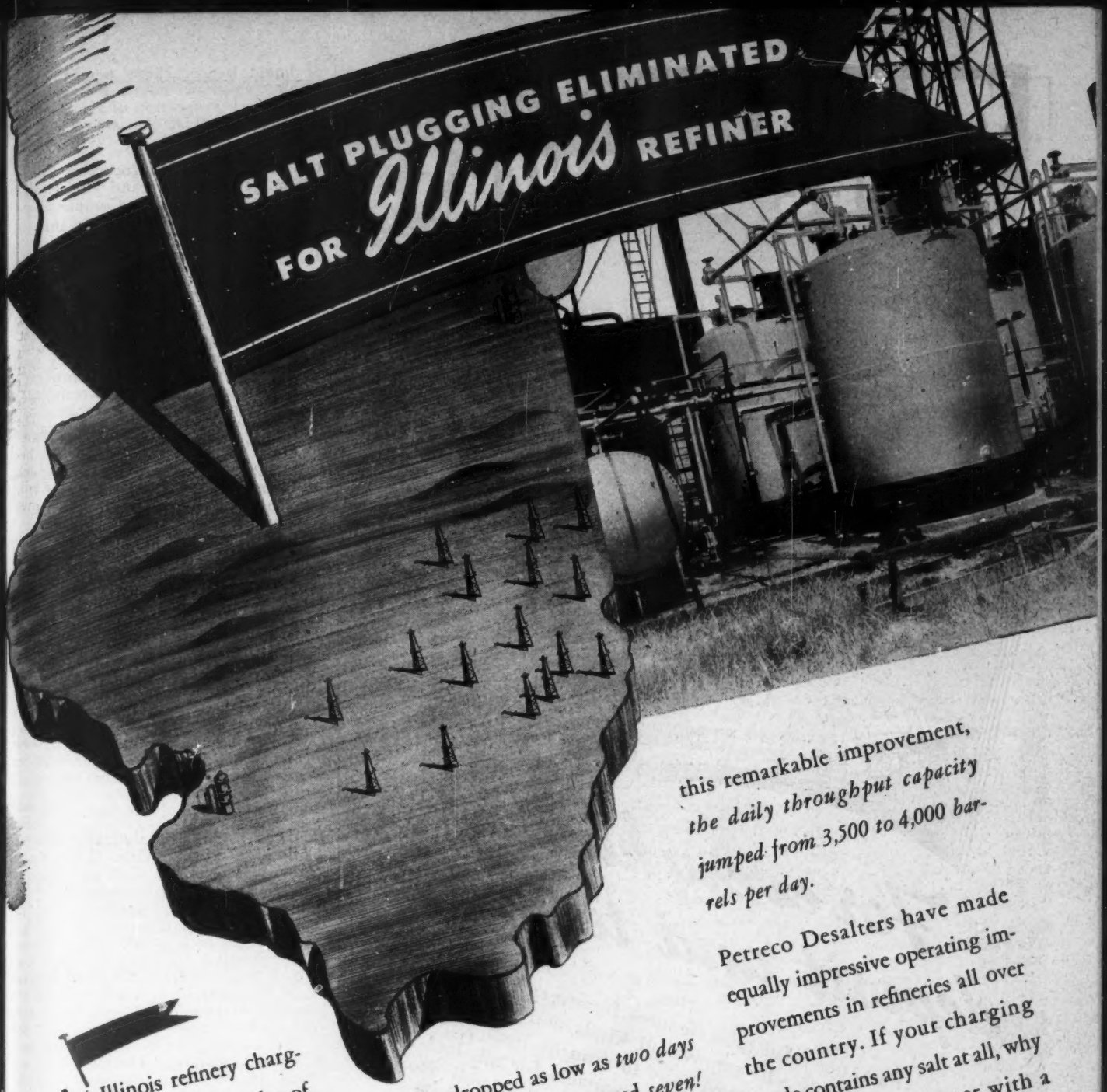
The invention rests in a process for production of aromatic products with a higher number of C atoms per mol from light olefins, in the course of which the light olefin is passed over the oxides of zirconium, hafnium, thorium, cerium or of the metals of the rare earths, or over mixtures of these oxides, at a temperature of about 600 to about 800° C. and preferably at about atmospheric pressure.

U.S.P. 2,335,610. Dehydro-Aromatization System. W. B. Plummer to Standard Oil Company (Indiana).

Hydrocarbons such as naphtha and heavier oils are reformed to produce aromatic motor fuel of high octane number by a method which comprises vaporizing said hydrocarbons, contacting the vapors with a dehydro-aromatization catalyst at 850-1075° F. and a pressure above 50 but below 450 pounds with a space velocity of about 0.04 volumes to 10 volumes of liquid hydrocarbons per volume of catalyst space per hour to effect dehydrogenation and aromatization in a mild-condition step and a severe condition step respectively to produce hydrogen of varying degrees of purity, separately collecting relatively pure hydrogen produced in the mild condition step and hydrogen of a low degree of purity produced in the severe condition step, introducing the relatively pure hydrogen together with the hydrocarbon vapors into contact with the catalyst when the catalyst is partially spent and discharging at least a part of the relatively impure hydrogen from the system. The catalysts may be made by impregnating activated alumina or other supports with molybdic acid, ammonium molybdate or any other catalytic compound decomposable by heat.

U.S.P. 2,336,783. Hydrocarbon Conversion. H. Fehrer to Process Management Company.

The properties of chromium oxide as an aromatization catalyst can be enhanced materially by the incorporation therein of zirconium oxide. Hydrocarbons having at least six C atoms per mol are passed over the catalyst at 325-650° C. at atmospheric or higher pressure. Space velocities of 0.1-3 volumes



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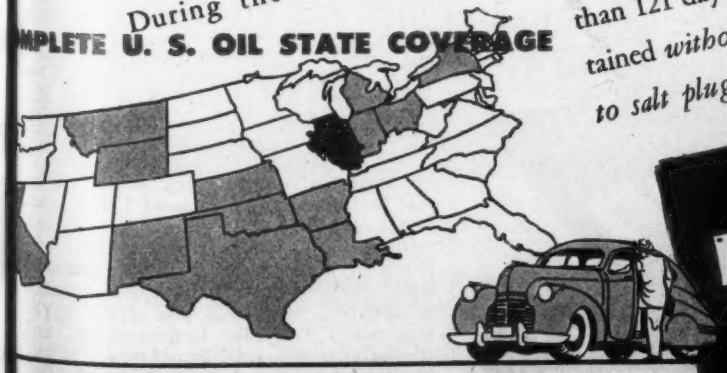

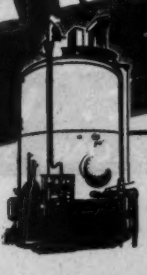

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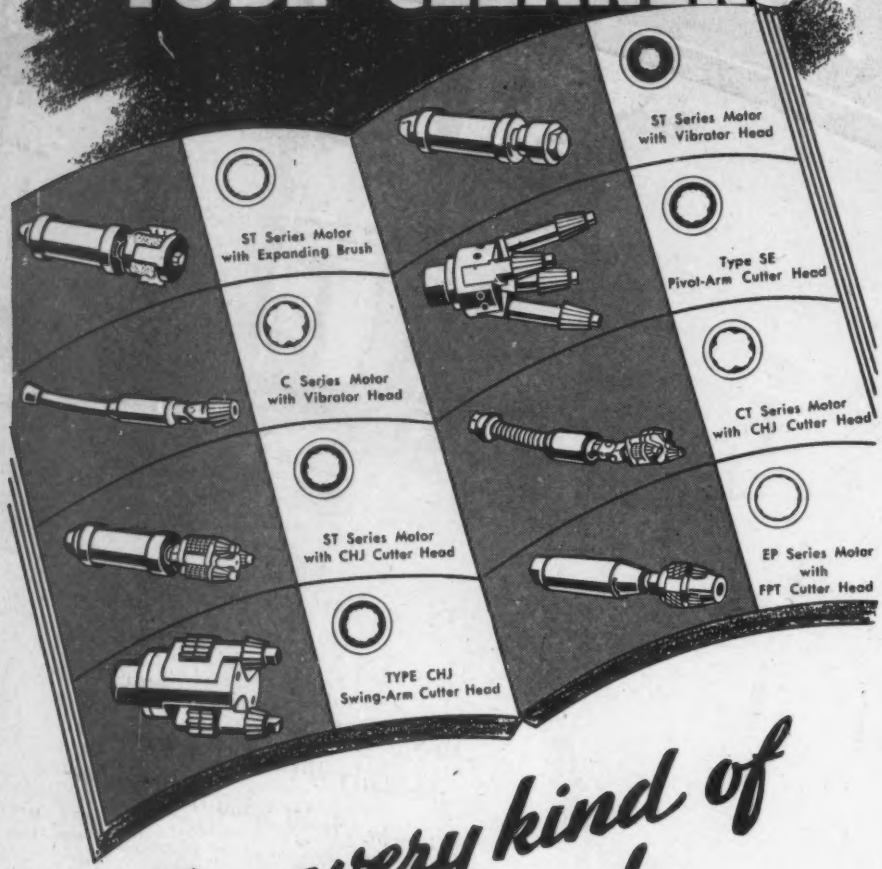
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of liquid hydrocarbons per volume of catalyst space per hour are employed. A satisfactory proportion of zirconium oxide in the catalyst consists of 5-20 percent.

U.S.P. 2,336,900. Hydrocarbon Conversion. H. S. Taylor and H. Fehrer to Process Management Company.

An improved catalyst for the conversion of aliphatic hydrocarbons having at least six C atoms per mol to aromatic hydrocarbons by dehydrogenation and cyclization at 325-650° C. is described. The customary gel-type catalysts produce besides aromatics also a substantial proportion of unsaturated aliphatic hydrocarbons. This is avoided by modifying the catalyst by incorporating therein a second catalytic material which functions primarily as a cracking catalyst at the operating temperatures. Metallic nickel is such a catalyst.

U.S.P. 2,337,190. Cyclization of Hydrocarbons. B. S. Greensfelder and R. C. Archibald to Shell Development Company.

Open chain hydrocarbons containing from 6 to 12 C atoms per mol are contacted at 350-700° C. and at 1-10 atm. pressure with a cyclization catalyst comprising a compound of a metal of the first transition series, such as chromic oxide, compounded with a promoter and supported on an inert carrier such as activated alumina. The promoter consists of 2.5-20 percent (based upon the amount of metal in the active cyclization component of the catalyst) of a rare earth having an atomic number between 57 and 72 and from 6 to 30 percent of an element selected from the group consisting of sodium plus potassium, potassium, rubidium and caesium.

U.S.P. 2,338,573. Catalytically Processing Hydrocarbon Oils. G. D. Creelman to The M. W. Kellogg Company.

Petroleum naphtha is fractionated into lighter and heavier fractions, which are separately heated to a high conversion temperature, such as 875° F. or higher. The vaporized fractions are subjected at such temperatures (875-1050° F.) and at 30-450 pounds pressure and in the presence of added hydrogen (at a concentration of about 0.5-8 mols per mol of hydrocarbon) to the action of a solid aromatizing catalyst. The catalyst is disposed in an extended path through which the hydrocarbon vapor is conducted in such a way that the lighter fraction is passed through the whole extent of the vapor path while the heavier fraction is passed through a lesser extent of the vapor path only.

U.S.P. 2,342,090. Production of Aromatic Compounds. A. N. Sachanen and R. C. Hausford to Socony-Vacuum Oil Company.

A process for obtaining high yields of alkyl bicyclic aromatic hydrocarbons boiling between about 220° C. and 320° C. and alkyl tricyclic aromatic hydrocarbons boiling between about 320 and 420° C. in substantially pure state, from an aromatic petroleum stock having an initial boiling point of at least 550° F., having a specific gravity of at least 0.92 and containing upwards of 40 percent aromatic hydrocarbons including aromatic hydrocarbons having complex aromatic structures, other than said alkyl bicyclic and alkyl tricyclic hydrocarbons, and the balance normally liquid non-aromatic hydrocarbons, is described, which comprises subjecting said aromatic petro-

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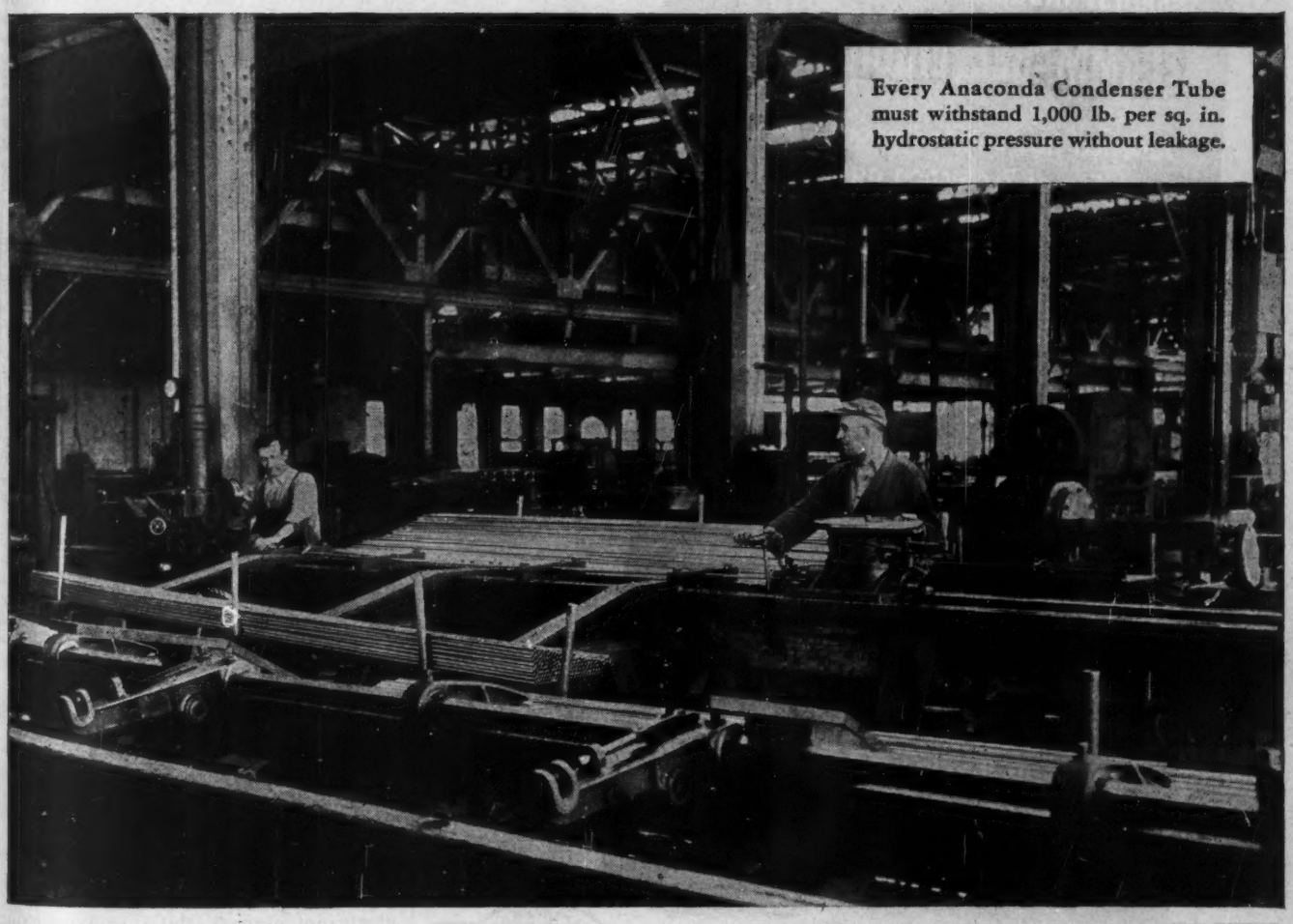

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leum stock in a reaction zone to thermal cracking conditions including temperatures varying between about 850 and about 1000° F., for a period sufficient to crack substantially all the non-aromatic hydrocarbons boiling within the boiling ranges of said alkyl bicyclic and alkyl tricyclic aromatic hydrocarbons, to produce gas, liquid non-aromatic hydrocarbons boiling within the gasoline-boiling range and coke, and to simplify the complex aromatic structures initially present in the petroleum stock to yield a liquid consisting essentially of a mixture of said liquid non-aromatic hydrocarbons and aromatic hydrocarbons boiling within the gasoline-boiling range, and polycyclic aromatic hydrocarbons, withdrawing said liquid from said reaction zone, and subjecting said liquid to distillation to obtain fractions of a mixture of hydrocarbons boiling within the gasoline-boiling range, and said alkyl bicyclic and alkyl tricyclic aromatic hydrocarbons in substantially pure state.

U.S.P. 2,343,851 and 2,343,852. Catalytic Conversion of Hydrocarbons. A. V. Grosse and J. C. Morrell to Universal Oil Products Company.

Higher-boiling hydrocarbon fractions are converted without substantial decomposition into low-boiling hydrocarbon fractions containing increased proportions of cyclic hydrocarbons by a process of contacting the higher-boiling fractions at 750-1250° F. with catalysts composited from refractory silica-alumina catalytic masses together with supported oxides of the elements in the left hand columns of group V of the periodic table, comprising vanadium, tantalum and columbium.

U.S.P. 2,344,318. Treatment of Hydrocarbons. W. J. Mattox to Universal Oil Products Company.

A process for producing aromatic hydrocarbons from aliphatic hydrocarbons containing straight chains of 6 to 12 C atoms per mol is described which comprises dehydrogenating and cyclizing said aliphatic hydrocarbons at a temperature of the order of 450-650° C. under a pressure in the range of substantially atmospheric to approximately 100 pounds per square inch for an average time of contact of approximately 0.1-60 seconds in the presence of a dehydrocyclization catalyst comprising essentially a major proportion of thorium oxide and relatively minor proportions of magnesium oxide and an oxide of chromium.

U.S.P. 2,345,096. Catalytic Conversion of Hydrocarbons. R. E. Burk and E. C. Hughes to The Standard Oil Company (Ohio).

Non-benzenoid hydrocarbons are converted to aromatics and deposition of coke on the catalyst is inhibited in the process disclosed. The catalyst consists of a gel-type co-precipitated combination of oxides of copper, aluminum and chromium, the copper oxide presenting 1-10 mol percent the aluminum oxide 81-60 mol percent, the chromium oxide 18-30 mol percent. The operating temperature of the catalyst is 750° F. and upward. A hydrocarbon gas of four C atoms per mol or less may be supplied with the hydrocarbon feed, at a rate of 1-10 mols per mol of naphtha. Preferably a supply of hydrogen at 0.1 to 10 mols per mol of naphtha is also provided. Off-gas from the process containing a

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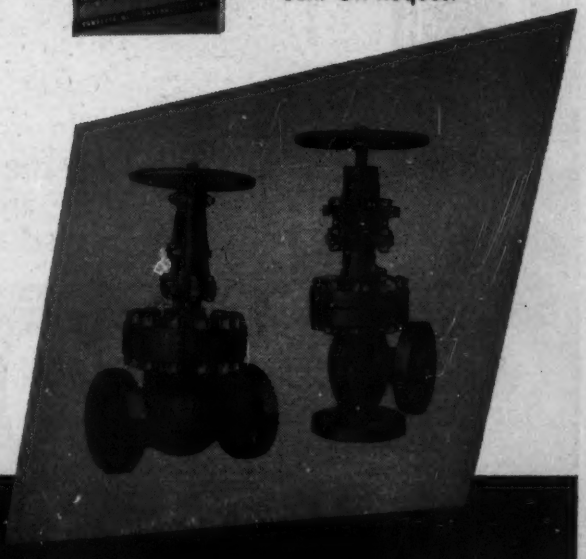

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C_4 hydrocarbon and hydrogen may be recycled. Flow rates of naphtha may be 0.1 to 10 liquid volumes per volume of catalyst per hour. In operating with a supply of hydrogen, temperatures of 750-1200° F. are applicable. The operating pressure may be 400 pounds when introducing hydrogen as the only gas, 800 pounds when C_4s are employed.

U.S.P. 2,344,330. Conversion of Hydrocarbons. J. F. Sturgeon to Universal Oil Products Company.

The invention comprises a process for the aromatization of hydrocarbons containing at least six C atoms per mol in straight-chain or ring arrangement by subjecting the hydrocarbons to contact with catalysts prepared by forming mixed metal oxide hydrogels containing at least one component having a dehydrogenating catalytic activity in a partially dehydrated condition, filtering the hydrogels to separate mechanically removable water, freezing and then thawing the filtered hydrogel to destroy its gelatinous structure, filtering, drying and washing to remove water-soluble impurities, forming into particles and calcining to produce an active catalyst. Reaction temperature is 750-1400° F.

U.S.P. 2,345,575. Process of Preparing Gasoline of Low Gum-Forming Tendency. R. E. Burk and E. C. Hughes to The Standard Oil Company (Ohio).

Naphtha is aromatized by a catalyst composed of a co-precipitated gel, consisting of 70-82 mol percent of aluminum oxide and 18-30 mol percent of chromium oxide at a temperature of 750-1200° F. and pressure of 40-180 pounds in the presence of hydrogen. Gum-forming constituents in the product can then be hydrogenated with the same catalyst at 580-900° F.

U.S.P. 2,345,718. Treating Oils to Produce Anti-Knock Gasolines or Aromatic Type Liquids. J. S. Walton to Standard Oil Development Company.

Hydrocarbon oils predominantly non-aromatic in character, such as kerosine or gasoil are vaporized, the vapors mixed with a finely divided catalyst, consisting of clay, elements of the third and sixth group of the periodic system and oxides of elements of the third and sixth group and the mixture passed under super-atmospheric pressure through an initial conversion zone at 800-975° F. Lower molecular weight paraffin hydrocarbons and olefins are obtained and passed to a second conversion zone at up to 1050° F., where more olefins and some cyclic products from olefins are formed. The reaction mixture is passed to a third reaction zone, maintained at up to 1450° F. where a major portion of the hydrocarbons present is converted to aromatics.

U.S.P. 2,349,045. Dehydro-Aromatization. E. T. Layng and V. Voorhees to Standard Oil Company (Indiana) and The M. W. Kellogg Company.

Valuable cyclic hydrocarbons such as toluene are produced from petroleum naphtha by contacting it with an aromatization catalyst preferably consisting of an oxide of a sixth group metal mounted on alumina. 2-10 percent molybdenum oxide or 8-40 percent chromium oxide on alumina have been found to give excellent results. Pressure in the range of 30 to 450 pounds and temperatures of 875-1075° F. are maintained in the reaction zone, in the presence of 0.4-8 mols of hydrogen and at a space

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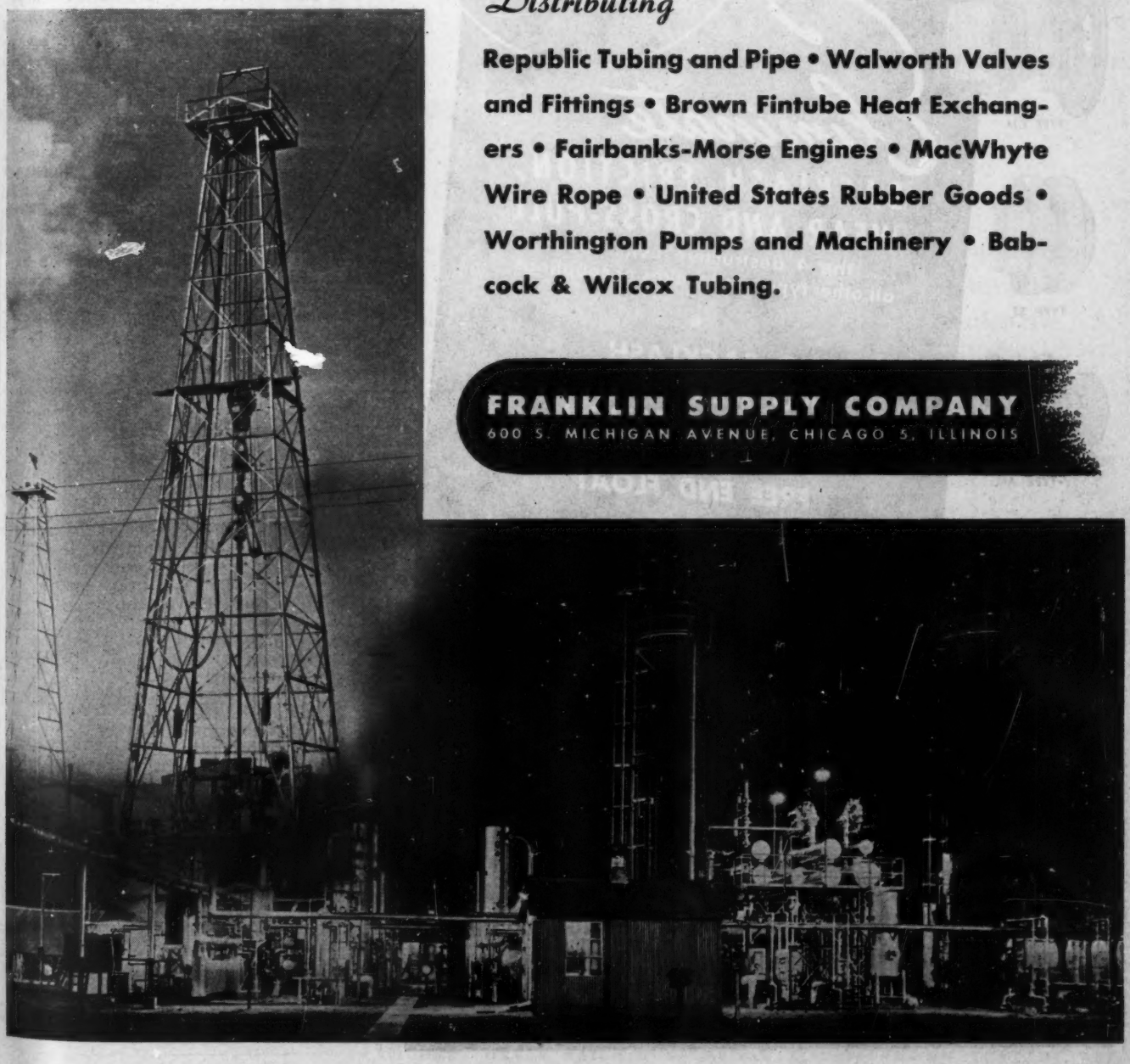

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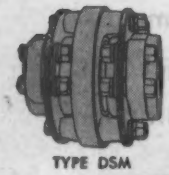
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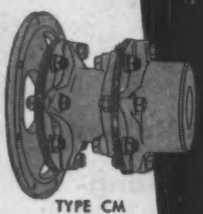
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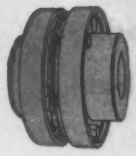
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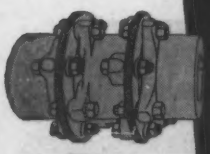
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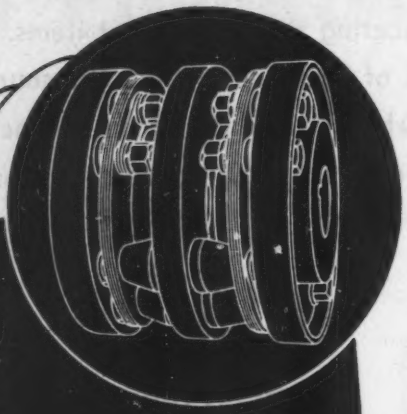

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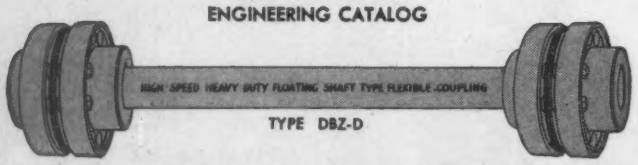

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velocity of 0.4-10 volumes of liquid naphtha per volume of catalyst space per hour. A gas fraction rich in hydrogen is separated from the effluent, heated above the reaction temperature to supply a part of the heat of reaction and recycled.

U.S.P. 2,349,825. Method for the Aromatization of Aliphatic Hydrocarbons. E. T. Layng to The M. W. Kellogg Company.

The process for producing aromatic hydrocarbons and hydrogen from aliphatic hydrocarbons of six or more C atoms in a straight chain is carried out in two zones. The catalyst employed in the two zones may be the same or a different one and should consist of a dehydrogenating-cyclizing material comprising a compound selected from the oxides and sulfides of the metals of the sixth group of the periodic table. In the first zone temperatures of 850 to 1000° F. and a moderate pressure, such as e.g., 100 pounds are employed and the reaction is carried out in the presence of excess hydrogen. Naphthenic hydrocarbons are formed, which are then passed into the second zone at lower pressure and lower hydrogen concentration and converted to aromatics. There is little carbonaceous material deposited on the catalyst.

Robert F. Hardwicke Named PAW Chief Counsel

Robert F. Hardwicke has been named chief counsel for Petroleum Administration for War, succeeding J. Howard Marshall who resigned to again practice law at San Francisco after serving the bureau since 1941. Hardwicke, who is senior member of Hardwicke & Cheek, Fort Worth, has been associate chief counsel for PAW since November, 1943. He has practiced law in the Southwest since graduation from Texas University in 1911, principally for oil interests.

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Methyl, ethyl, n-propyl or iso-propyl azides
Nitrogen tetrasulfide
Tetraiodo ethylene
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Quinoxaline
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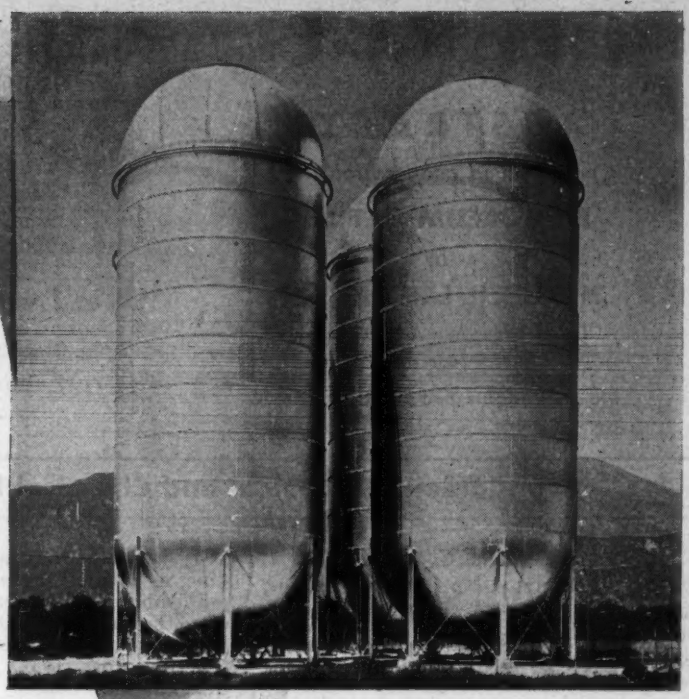
Mellisic acid
Monoallyl ether of ethylene glycol
1-Methyl imidazole
2-(Alpha hydroxy-n-propyl) piperidine.



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Photostat copies of original articles will be supplied at cost by The Leslie Laboratories. Complete or limited bibliographies covering special topics by title, by abstracts, or in complete manuscript, will also be prepared and furnished at reasonable cost by the Laboratories.

Fundamental Physical and Chemical Data

Hexamethylethane. *G.* CALINGAERT, H. SOROOS, V. HNIZDA AND H. SHAPIRO. *Jour. Amer. Chem. Soc.* **66** (1944) pp. 1389-94.

Hexamethylethane has attracted the attention of chemists and physicists because of its unusually branched and symmetrical structure, and the effect of this structure on its physical properties. This branched octane melts above 100° C., or 157° C. above the normal isomer, and as high as hexacontane ($C_{60}H_{122}$), although it retains the volatility to be expected at its low molecular weight. Hexamethylethane was prepared by the condensation of 2,3,3-trimethyl-2-chlorobutane with methylmagnesium chloride, and it was purified by fractional distillation in a specially-designed pressure still. The method of preparation is described in some detail, as well as the pressure still used in the purification. Freezing point and melting point curves were obtained for the two best fractions. The best fraction gave a freezing point of 100.63° C. and a freezing point lowering when one-half frozen of 0.06° C. From these data the purity of the sample was calculated to be 99.96 ± 0.04 mole percent and the freezing point of pure hexamethylethan was estimated to be 100.69° C. The vapor pressure of the purified hydrocarbon was measured over the temperature range 0 to 100° in a Bremer-Frowein tensimeter, and from the data obtained the following equations were derived for the vapor pressure hexamethylethane:

Solid: $\log P\ (mm.) = 7.78882 - 1625.7/(t + 226)$

Liquid: $\log P\ (mm.) = 6.87665 - 1327.8/(t + 226)$

Computations from the vapor pressure data of the heats of fusion, vaporization and sublimation at the melting point, using the Clausius-Cpaleyron equation, gave the values 1700, 7550 and 9250 calories/gram mole respectively. The calculated boiling point is 106.30 ± 0.02° C., and the calculated heat of vaporization at the boiling point is 7530 calories/gram mole. Determinations of the density and refractive index of solid hexamethylethane gave the values: d^{294} 0.823 g./ml., and $n^{20}D$ 1.4695.

Viscosities at the Boiling Point of Some Primary Amines, Cyclohexane and Some of Its Derivatives. J. NEWTON FRIEND AND W. D. HARGREAVES. *Phil. Mag.* **35** (1944) pp. 57-64.

Viscosity-temperature curves are given for toluene, benzene, chlorobenzine, anisole, benzylamine, m-toluidine, o-toluidine, p-toluidine, aniline, o-chloroaniline, o-anisidine. Measurements were made over the range 40-220° C. The main object of the work was the evaluation of the rheochors of the amine groups and the determination of the effect of a six carbon ring formation. The mean value found for the rheochor of the NH_2 group is 20.6. Viscosity-temperature curves are given for methylcyclohexane, cyclohexane, cyclohexyl chloride, cyclohexylamine, cyclohexyl bromide, cyclohexanol. The temperature range covered was 20-160° C. Replacement of hydrogen in cyclohexane by Cl, NH_2, Br, OH progressively increases the viscosity, whereas CH_3 group reduces it.

Viscosities of Unsaturated Six-Membered Isocyclic Compounds. J. N. FRIEND AND W. D. HARGREAVES. *Phil. Mag.* **35** (1944) pp. 136-47

Viscosity-temperature curves and density-temperature curves, over the range 0-80° C. are given for cyclohexane, cyclohexene, 1,3-cyclohexadiene, and benzene. The successive removal of each H_2 from C_6H_{12} down to C_6H_6 leads to an increase in the density. The viscosity, however, drops, first rapidly in hexene, to a minimum in hexadiene, then rises slightly to benzene. The effect of substitution in the benzene ring is more marked than in cyclohexane. New measurements of densities and viscosities are given for a number of organic compounds. The rheochor of the phenyl group in various compounds was determined.

Chemical Compositions and Reactions

Synthesis of Polyenes. IV. M. S. KHARASCH, W. NUDENBERG AND E. K. FIELDS. *Jour. Amer. Chem. Soc.* **66** (1944) pp. 1276-9.

The authors studied the scope and mechanism of the reactions involved between organic halides and sodamide or potassium amide in liquid ammonia. They conclude that the alkali amides react with organic halides of the type RCH_2X to yield products such as $RCH{=}{=}CH.R$ only if the radical R is strongly electronegative. That is, R must be a, β-unsaturated (e.g., vinyl), or aromatic (e.g., phenyl), or an acyl (R_1CO) group. The experimental work done in studying the condensing action of sodamide on cinnamyl chloride, phenacylbromide, 2,2'-dibromomethylbiphenyl, 1,4-dibromobutene-2 and geranyl chloride is described. The same reagent also condenses benzyl chloride with allyl and methylallyl chlorides. The mechanism of the sodamide condensation is discussed in some detail.

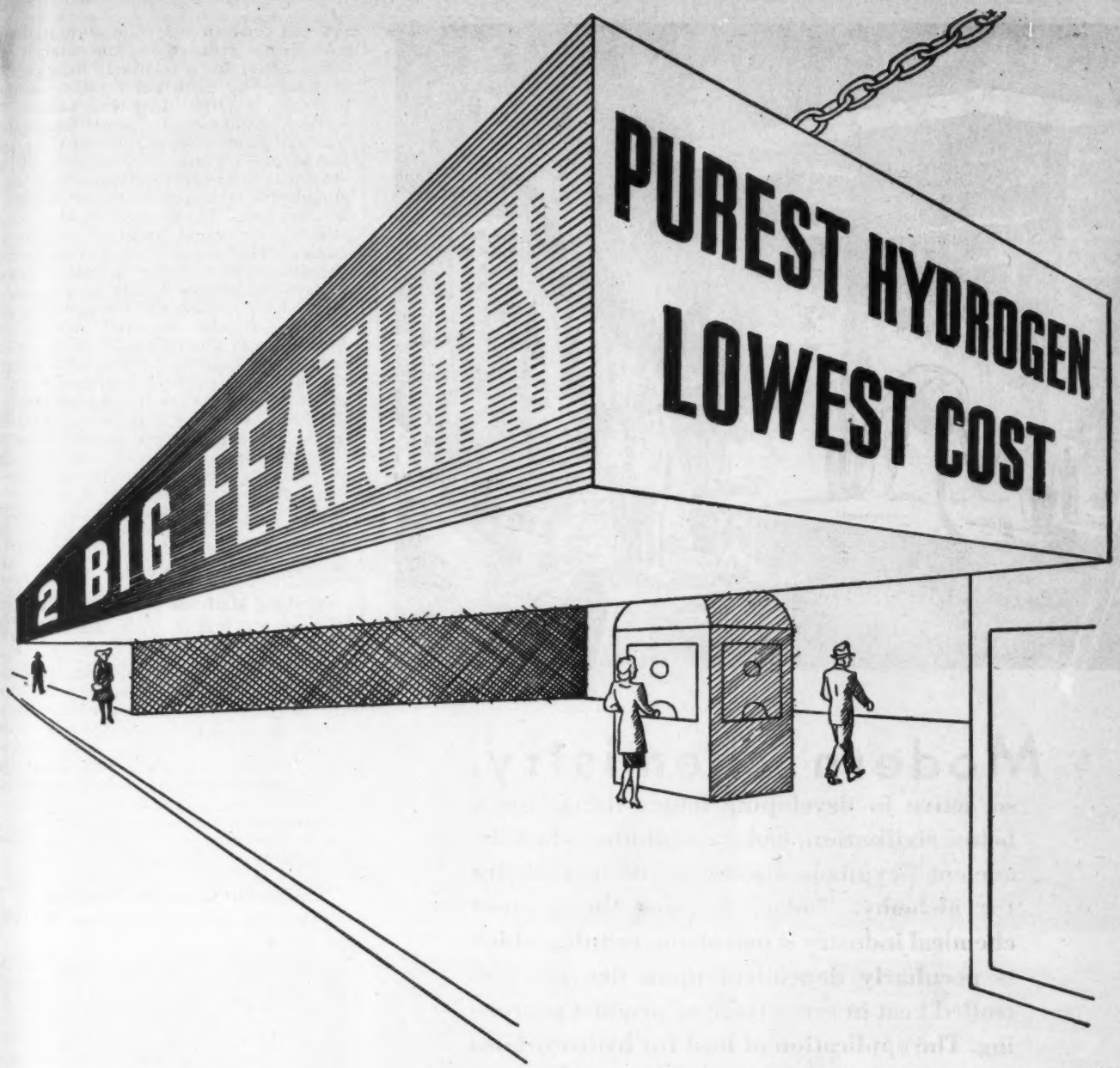
The Hydrogenation of Ethylene, Propylene and 2-Butene on Iron Catalysts. P. H. EMMETT AND J. B. GRAY. *Jour. Amer. Chem. Soc.* **66** (1944) pp. 1338-43.

The hydrogenation of ethylene, propylene and butylene on nickel catalysts has been extensively studied but little work has been reported on the hydrogenation of these gases over active iron catalysts. The paper reports measurements on the kinetics, temperature coefficient, and influence of promoter on the hydrogenation of ethylene, propylene, and 2-butene over six different catalysts. The preparation of each catalyst is described. The experimental apparatus and procedure are described in some detail. Data secured in the course of the investigation are presented in tabular and graphical form.

Manufacture: Processes and Plant

Synthetic Toluol from Petroleum by Hydroforming Process. H. G. M. FISCHER AND A. B. WELTY, JR. *Chem. & Met. Engr.* **51** (1944) pp. 92-5.

Recognizing the imminence of war, Army Ordnance rushed o completion a plant at the Baytown refinery of the Humble Oil & Refining Company for the production of nitration grade toluol from petroleum. During the year following Pearl Harbor this plant supplied over half of the toluene used in America to make TNT. The toluol present in crude petroleum varies widely. A table is given showing the content of various crude oils. The process used is hydroforming, involves the recirculation of hydrogen rich gas to the catalyst chamber and operation at moderate pressure on



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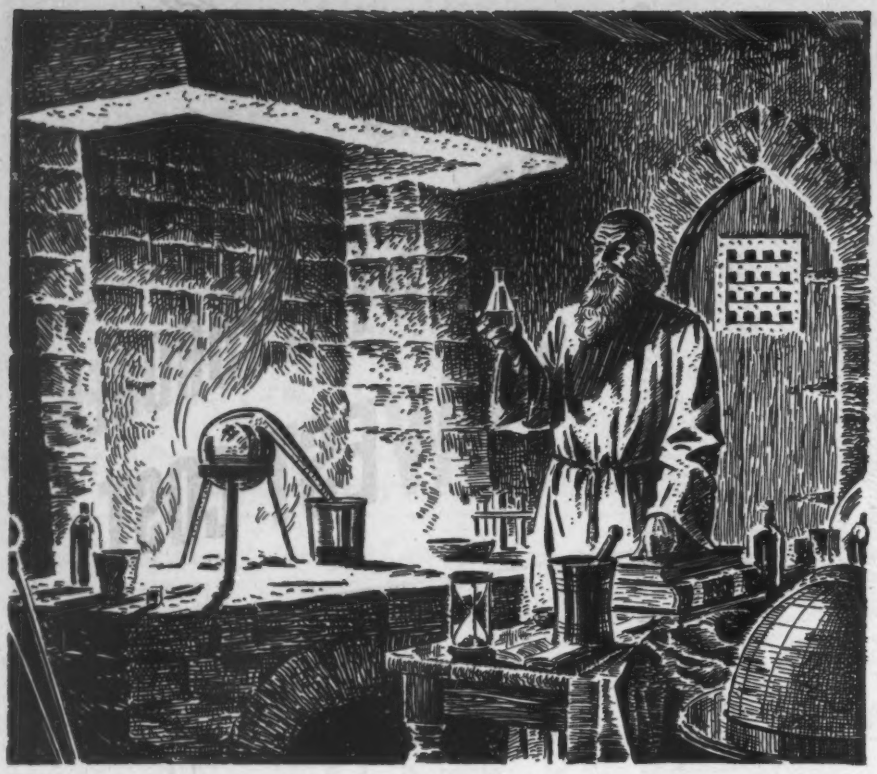

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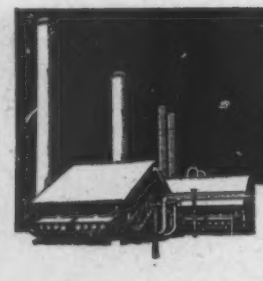

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selected feed stocks. The formation of coke is thus reduced and the catalyst remains active for a relatively long period of time. The principal reaction in the process is the dehydrogenation of methylcyclohexane to give toluene and free hydrogen. A flow sheet of the plant and several pictures are included. Yields obtained in hydroforming pure compounds are tabulated. Thus methylcyclohexane gives an 85 percent of toluene and a 93 percent yield of total aromatics. The success of a commercial operation for making nitration grade toluene did not rest solely on a practical method for making the toluene from petroleum. It also required solving the problem of separating it from other compounds boiling at the same temperature so as to produce a nitration grade product. Separation by superfractionation alone was not satisfactory because of the closeness of the boiling point of the compounds involved and the fact that in the presence of other components the toluene distilled over a relatively wide temperature range, perhaps 215-231° F. The procedure used by Humble is not described because of secrecy order restrictions.

Modern Methods of Motor Fuel Production. G. EGLOFF. *Jour. Inst. Petr.* 30 (1944) pp. 173-192.

The author reviews methods of motor fuel production, including cracking, reforming, naphtha gas reversion, polyforming, catalytic cracking with static beds, catalytic cracking with moving beds, catalytic cracking with fluid catalysts, polymerization, dehydrogenation, hydroforming, isomerization, alkylation of aromatics, and some modifications of these procedures. Typical simplified flowsheets are included.

Thermofor Catalytic Cracking. F. J. ANTWERPEN. *Ind. & Eng. Chem.* 36 (1944) pp. 694-8.

The history of the development of the Thermofor process is reviewed. In 1939 Socony-Vacuum engineers developed the Thermofor kiln for burning the carbon out of the clay used in filtering lubricating oil. Data were obtained on clay flow distribution, heat generation, attrition, diffusion rates in carbon burning, and other engineering matters. In 1941 a continuous Thermofor catalytic cracking plant was built with a capacity of 400-500 barrels per day. The feed to a Thermofor unit is any vaporizable distillate with an initial boiling point of over 400° F. The vapors are heated to 850-950° F. The vapors pass to the reactor, entering at the bottom and rising against the descending catalyst. During this passage the chemical changes that convert it to aircraft fuel occur and the hydrocarbon vapors pass to a conventional fractionator. The reactor operates at a pressure of 10-15 pounds per square inch. The temperatures in the reaction zone remain 850-950° F. The ratio of catalyst to oil can vary from 1 to 8, depending on design and the product desired. The catalyst from the base of the reaction chamber is steam-purged to remove hydrocarbon vapors and it then passes through a depressuring pot to the bottom of the elevator that carries it to the top of the Thermofor kiln in which it is regenerated. The consumption of catalyst has been less than one-quarter pound per barrel of oil charged. The unit has been on stream 92.6 percent of the time since it started. The Thermo-

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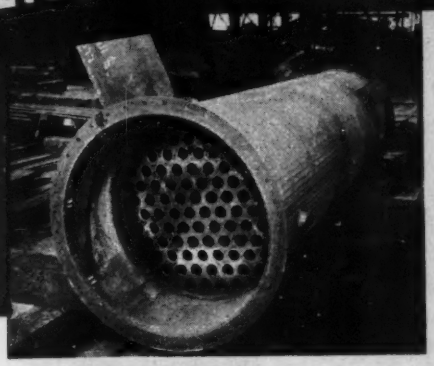

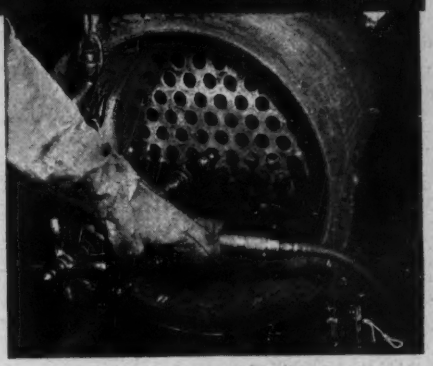

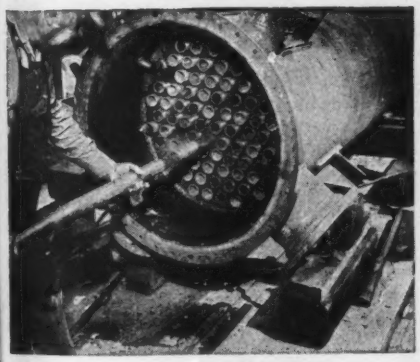

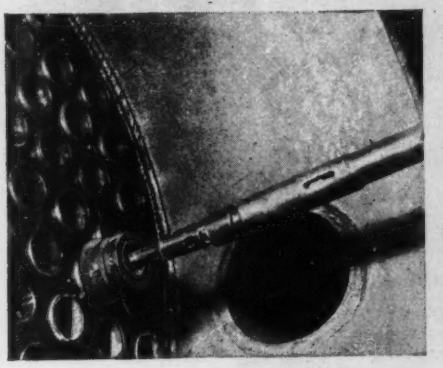

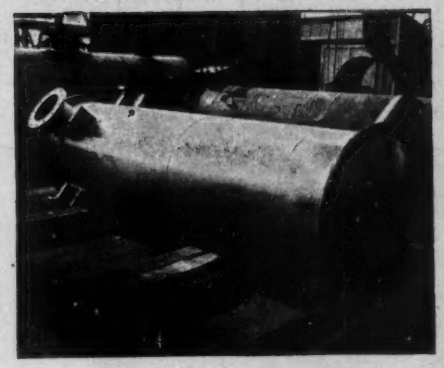

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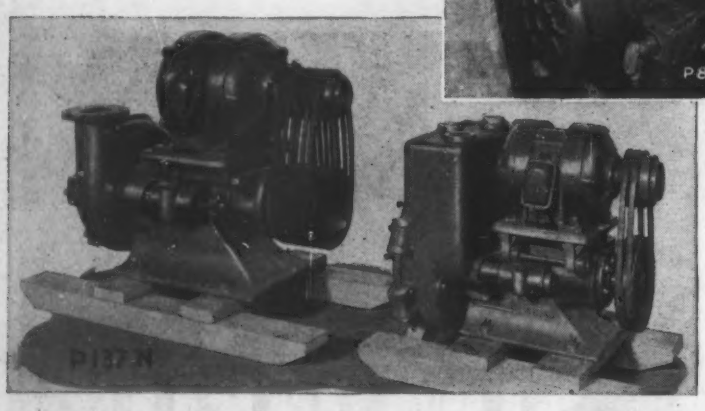

Heat and corrosion resistant properties of Amsco Alloy detailed in Bulletin 108.

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for regeneration kiln receives air at 10 inches water pressure and directs it into the clay, burns the carbon to the products of combustion to a residual carbon content of 0.2-0.5 percent by weight of catalyst. Steam-generating cooling coils are used to give control over temperature during regeneration. The heat is used to generate steam. The quantities generated are given. The product from the TTC unit is treated further either in a Houdry unit or another TTC unit to make aviation fuel. Yields of properties of products from single-pass and recycle operation are given. A two-pass operation with TCC and clay catalyst gives a 7 pound vapor pressure aviation gasoline containing 20-30 percent of aromatics and an octane number of 77-80. The properties of typical aviation gasoline made from naphthenic, paraffinic, and high sulfur gas oils are given, as well as the properties of typical motor gases made by TCC cracking of gas oils of these same types. The cost of TCC processing amounts to 7 cents per barrel of gas oil charge including operation, supervision, fuel, steam, power, water, laboratory supervision, and maintenance.

Determining Fall or Rise Velocity of Spheres in Fluids. R. C. BINDER. *Chem. & Met. Engr.* 51 (1944) pp. 104-5.

Stoke's law is commonly used in determining the settling rates of fine particles in a liquid or gas, but is inadequate in many important industrial processes where the flow of fluid relative to the particle is turbulent. For example, calculations for the rise or fall of "fluidized" solids in a gas stream require a technique for handling extreme turbulence. The author reviews the theory applying to a sphere rising or falling in a fluid. A type of plot of data is presented which permits velocity calculations to be made readily for a wide range of problems involving different fluids and different velocities.

Solvent Selectivity for Hydrocarbons. A. W. FRANCIS. *Ind. & Eng. Chem.* 36 (1944) pp. 764-71.

The choice of solvents for the selective extraction of hydrocarbon solutions depends upon several factors, including cost, availability, ease of recovery from the hydrocarbons, stability, selectivity for the desired or undesired type of hydrocarbon, and suitable degree of solubility at a convenient temperature. The critical solution temperature was chosen as a measure of affinity of hydrocarbons for various solvents. The critical solution temperature was used partly because a determination can be made in a few minutes and requires only about 1 cc. each of solvent and hydrocarbon. About 900 determinations of critical solutions temperatures were made, including determinations with over 100 different solvents of various types with ten representative hydrocarbons, two straight-chain paraffins, a branched-chain paraffin, two olefins, two naphthenes, paraffin wax, and two commercial oils. Aromatic hydrocarbons are too miscible with the solvents to observe critical solution temperature. The difference in critical solution temperature for the same solvent with different hydrocarbons is taken as a measure of the relative affinity or selectivity of the solvent for the two types of hydrocarbon. Selectivities for olefins, naphthenes, branched chains, type of oil, and molecular weight are calculated and

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plotted against each other to show the extent of interrelation. Effects of substituent groups in the solvents are estimated. The methyl and phenyl groups usually lower critical solution temperature about 40° C. The nitro and carboxyl groups raise it over 100° C. The data are presented in considerable detail in tabular and graphical form. A bibliography of 65 references is appended.

Automatic-Control Instrument Adjustment. L. H. ALLEN, JR. *Ind. & Eng. Chem.* 36 (1944) pp. 687-93.

The author presents a comparison of the methods of arriving at control instrument settings originally proposed by Ziegler and Nichols. Experimental data on obtaining instrument settings are given, and the relative merits of the two methods are compared. The reaction curve method and its use in evaluating processes for the application of automatic control is described in detail to supplement the description of the ultimate sensitivity method given a previous paper by the author. The investigation results reported confirm the reaction curve as a valuable tool for the instrument engineer. It offers a second and somewhat more accurate method of determining controller setting. The method can be used to study processes from the standpoint of their difficulty of control, and it offers a method of analyzing processes for possible rearrangement of equipment that would lead to improved process control. The data taken in the course of the work in the study of a commercial size acetone recovery unit are presented in some detail in tabular and graphical form.

Products: Properties and Utilization

Para-Petrol. *Petroleum* (London) 7 (1944) p. 99.

Because of the motor fuel shortage in Switzerland, the plan was adopted in 1940 for the blending of paraldehyde to form a compound called "Para." This was added to gasoline to the extent of 20 to 40 percent. The properties of paraldehyde are given. The material Para as used contains: acetaldehyde less than 0.02 percent, acetone 7.5 percent, paraldehyde 75.1 percent, esters 10.8 percent, and alcohol 6.6 percent. The high latent heat of Para gasoline somes requires warming of the intake manifold. Para has a slightly higher octane number than the straight gasoline. Inhibitors must be used to stabilize the mixture in storage. Carburetor jets must be increased slightly in size. The toxic properties of the vapor material are a disadvantage.

The Correlation of Cetane Number with Other Physical Properties of Diesel Fuels. Report by Diesel Index Panel of Standardization Sub-Committee No. 4—gas, Diesel and Fuel Oils. *Jour. Inst. Petr.* 30 (1944) pp. 193-7.

The problem of correlating the cetane number of a diesel fuel with other physical properties is a matter of some importance, as has been recognized by the introduction of several formulae designed to permit the assessment of ignition quality. It is desirable to establish a relationship between cetane number and any of the more easily determined physical properties, such as analine point, specific gravity, viscosity, and boiling range. As a rule, cetane number increases with increased paraffinicity. The purpose of the paper is to report the work carried out by the Diesel Index Panel of I. P. Sub-Committee No. 4. The Panel has reviewed correlation methods or formulae with a view to determining the degree of accuracy that can be expected by the calculation of cetane number as opposed to actual engine determination. On the basis of the work done by the committee it was concluded that the most accurate formula investigated is: Calculated Cetane No. = 175.4 log (mid-boiling point, °F.) + 1.98 (A.P.I. gravity) — 496. An alignment chart based on this equation is given. The above formula should not be used with oils containing ignition promoters.

Lubrication of Ball and Roller Bearings. 1. Principles. E. V. PATTERSON. *Petroleum* (London) 7 (1944) pp. 118-19.

The lubricant used on ball and roller bearings has three functions: first, to reduce friction; second, to prevent corrosion and erosion of the highly polished surfaces; and third, to dissipate the heat caused by friction and by the churning of the oil. The ideal lubricant would be a dense oil mist. Oil is preferred to grease when housing conditions permit. High speeds and temperature require oil lubrication, although greases can be used at somewhat reduced efficiency. For low temperatures oil lubrication is advisable. Greases for use on ball and roller bearings should be pure mineral oils, usually with lime or soda bases. Lime-base greases are valuable under damp conditions. Soda soap greases should not be used when water or dampness can enter the housing. Curves are given showing the maximum speeds possible when lime soap and soda soap greases are used. Aluminum soap greases are smooth, waterproof, and do not separate on melting. They are good lubricants for needle bearings. Lead base greases are not intended for use on ball and roller bearings but are used with hypoid gears as extreme pressure greases. The graphite added to a grease is definitely detrimental to ball and roller bearings.

The 1944 Edition of the I.P. "Standard Methods for Testing Petroleum and Its Products." Editorial Sub-Committee. *Jour. Inst. Petr.* 30 (1944) pp. 198-201.

The paper is an editorial review of the new edition of the I.P. "Standard Methods." No attempt is made to cover the changes in detail, but only the more salient modifications and innovations. The most notable feature of the new edition is the extension of its scope. It is the acknowledged intention of the Standardization Committee to cover not only methods for the whole gamut of products derived from petroleum but also methods for materials that incorporate petroleum products and that are frequently analyzed in petroleum laboratories. Thirteen methods are included for chemicals derived from petroleum, three for bituminous emulsions, and one for petroleum gases. Thermometer and hydrometer specifications are wholly revised. A number of new thermometers

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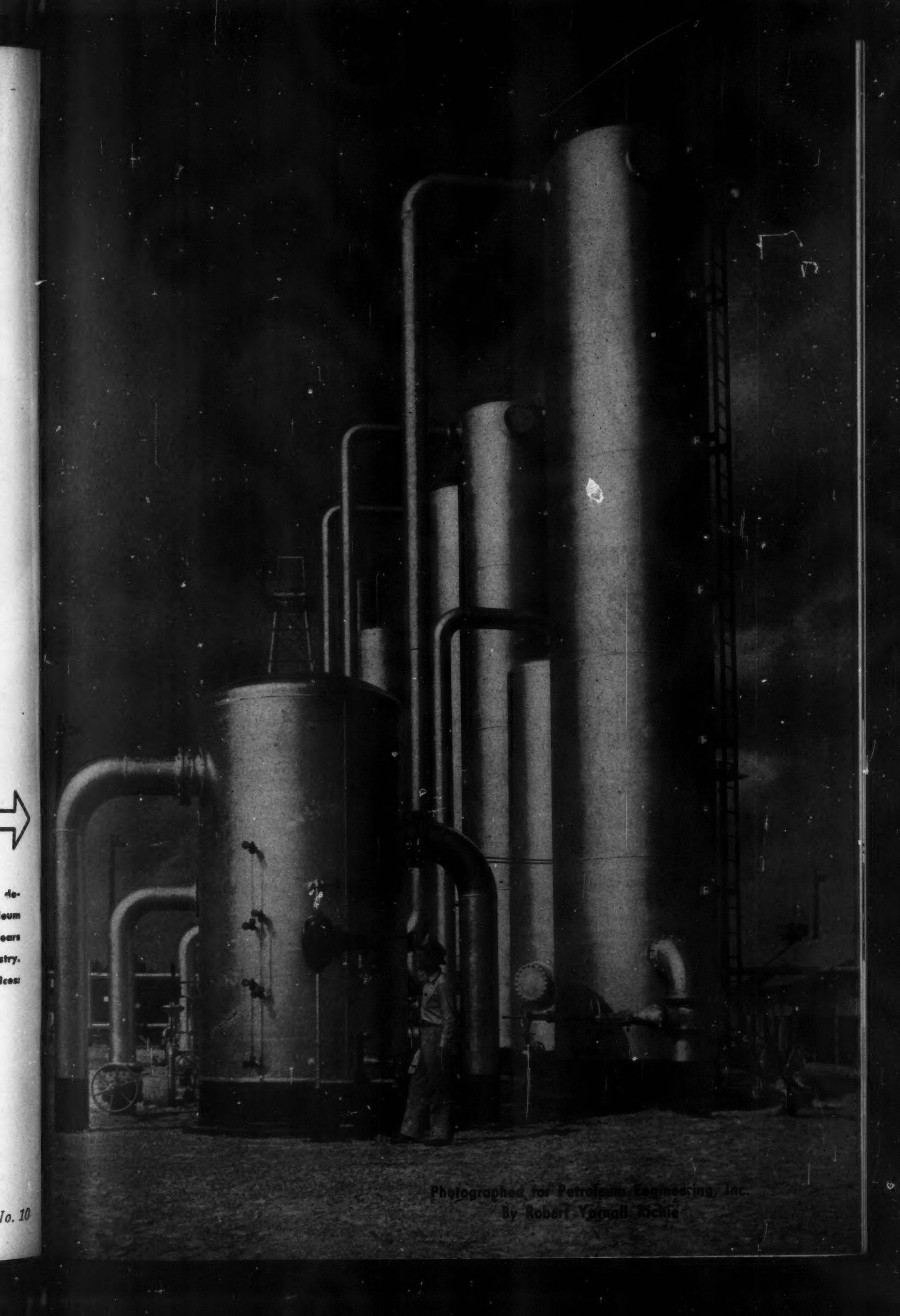

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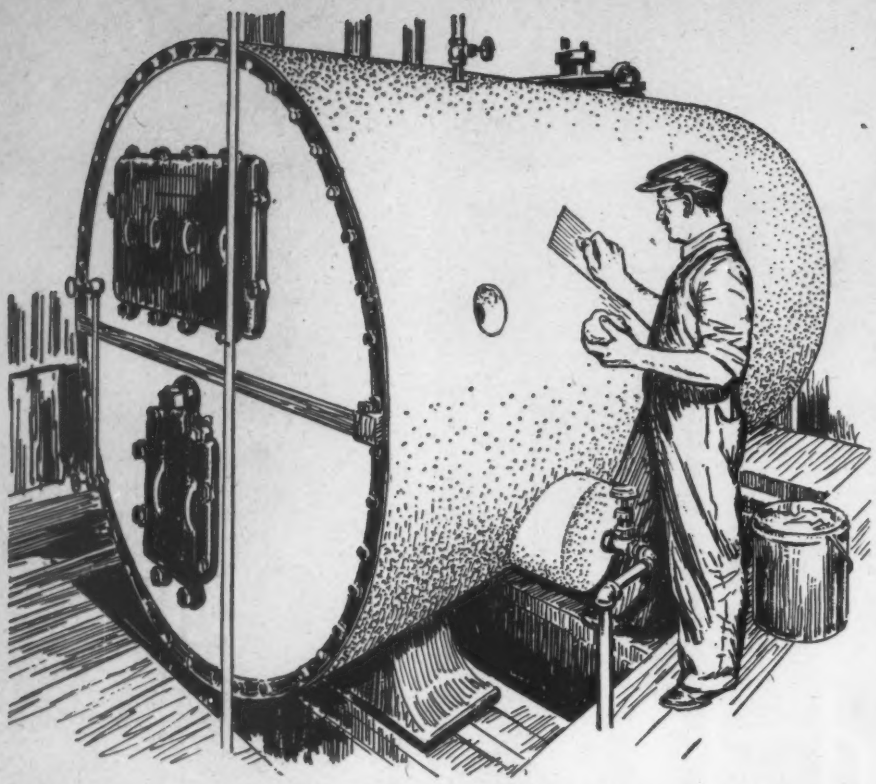

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are specified. Sections on sampling have been completely rewritten and made more comprehensive. The procedure for the evaluation of crude oils is included. New methods for light distillates include the water tolerance of motor fuels. A method is included for the low-temperature filtration of gas oils, providing a test for the tendency of fuels to clog gauges at low temperatures. New secondary reference fuels were calibrated for aviation-fuel testing. Methods for lubricating oils and asphaltic bitumens are given. It is the purpose of the Standardization Committee to reduce the present multiplicity of official petroleum tests and to work towards the ideal of a single collection of official Anglo-American test methods.

Automatic Distillation Apparatus for Gasoline Analysis. L. STEFFENS AND D. P. HEATH. *Ind. & Eng. Chem., Anal Ed.* **16** (1944) pp. 525-7.

The first step in the analytical examination of aviation gasoline is the separation of the sample by distillation into fractions consisting of substantially pure hydrocarbons where possible, or, as a compromise, a mixture of a few components. This requires a fractionating column with a large number of theoretical plates, and a small holdup per plate. The charge must be relatively large and the reflux ratio high. Under these conditions the distillation of a single sample may require several weeks of continuous operation. For this reason an automatic distillate-collecting device was constructed that makes possible the operation of a laboratory distillation unit with only occasional attention from the operator. Although the equipment was designed for gasoline analysis, it can be adapted to other distillations. It automatically collects the fractions of distillate and plots the distillation curve. It has been operated 24 hours per day for well over a year with an operator present only 8 hours per day. The apparatus is described in detail and the manner of its operation outlined.

Molecular Distillation: A New Path to Separation of Chemicals. T. R. OLIVE. *Chem. & Met. Engr.* **51** (1944) pp. 100-104.

It is not often that what may be described as a new unit operation becomes available in the field of chemical engineering. Molecular distillation may soon be so described because it offers a means of separating compounds of extremely high molecular weight, too high for separation by ordinary distillation, yet differs in almost every way from distillation of the ordinary equilibrium types. Until recently it was a laboratory tool developed by laboratory technicians. Now it has grown to plant scale and has moved into factory production. More than 5,000,000 pounds of fish liver oil were distilled last year in the United States to accomplish the separation of the odorous components and vitamin fractions from the bulk of the oil. Molecular distillation offers an opportunity for the separation and purification of high molecular weight materials such as synthetic polymers, plastics and plasticizers, rubber intermediates, synthetic lubricants, and heavy petroleum residues. The history of the development of molecular distillation is sketched, and the evolution of the molecular still from the early glass pot still through the glass still with outside con-

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Reed Valves are designed and constructed to provide ease of operation and positive shut-off under the most severe service conditions. A slight movement of the valve stem toward the open position pulls the trailing edge of the seating disc directly away from its seat. This action partially equalizes the pressure on both sides of the downstream disc and the valve is then moved to the full open position with exceptional ease.

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denser, the falling film still, and the vertical centrifugal disk still to the horizontal centrifugal disk still is reviewed. The throughput of the new still ranges from 500 to 1000 pounds per hour depending on the type of service. Such stills are able to take off six or more separate fractions, using two or three units in series. For stripping they can remove up to 20 percent as distillate in a single pass through one still. Costs of water, power, steam and other services are well within the limits of commercial economy. An even larger still, designed for a capacity of a tank car per day per plate, is now being engineered.

A Fractionating Molecular Still. H. J. WOLLNER, J. R. MATCHETT, AND J. LEVINE. *Ind. & Eng. Chem., Anal. Ed.* **16** (1944) pp. 529-31.

A falling film type of molecular still is described in which fractionation is effected through multiple distillation. A series of communicating stages of distilling and condensing surfaces, in which material of greater distillability is progressively advanced to forward stages and material of lesser distillability refluxed to rearward stages, is provided in a single unit. That is, the apparatus is such as to provide for progressive distillation while retaining the conditions necessary for molecular distillation. As in the simple still, distillate from an initial stage is condensed on the roof of the still and engaged by a trough during its downward flow. Instead of being removed from the still, however, the distillate is directed by the troughs to a succeeding heating surface, located at a higher level than the preceding one. Here the more readily distilled portions are again preferentially evaporated, and again carried to the next stage. While the more volatile material progressively advances, the less volatile material continuously regresses on the floor of the still toward rearward heating surfaces. By applying heat in graduated amounts to the several sections of the still, with the greater amounts applied at the initial stages, the desired rate of distillation and ratio of reflux can be maintained. The apparatus and its operation are described in some detail.

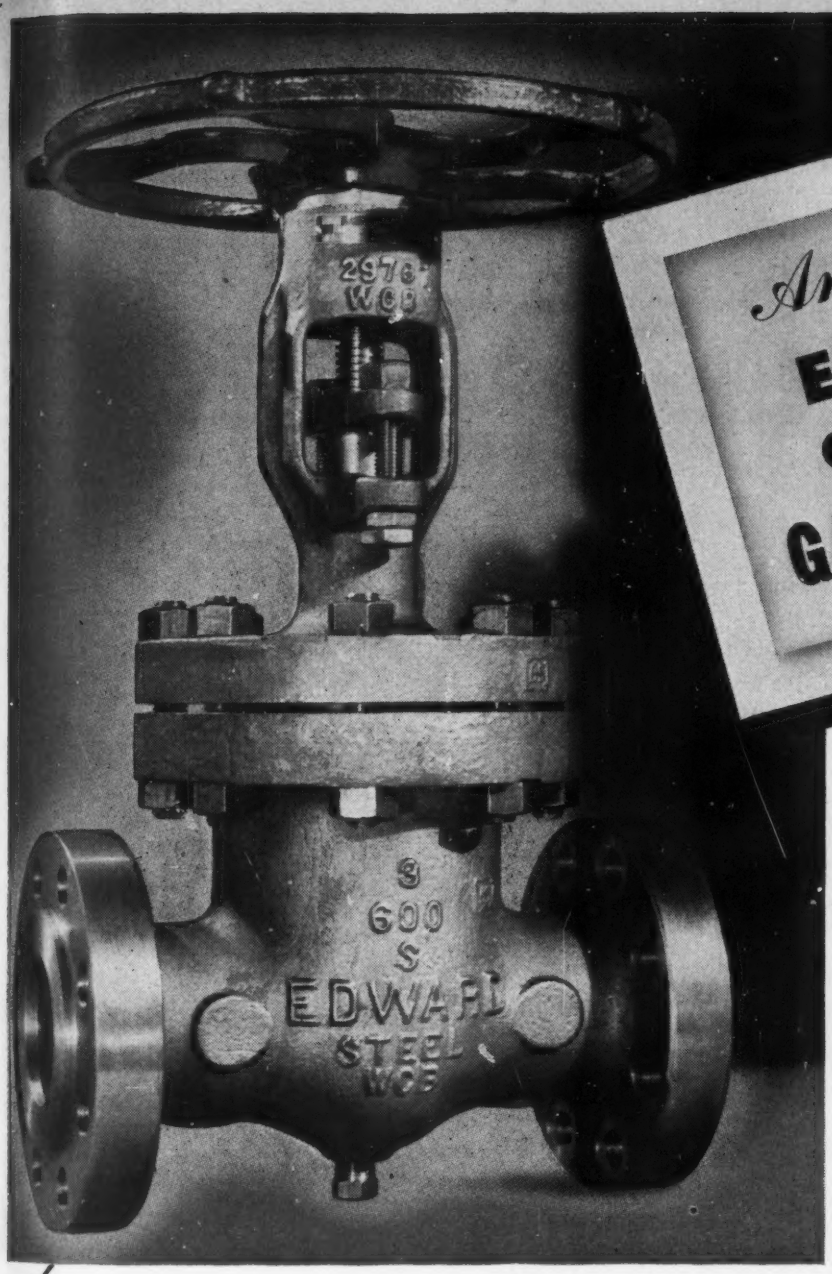
Tide Water Associated Appoints New Officers

H. S. Chase has been appointed a vice president of Tide Water Associated Oil Company and will continue in charge of manufacturing in the company's Eastern division. He has had more than 22 years of service with the company in refining operations and until early last year was general superintendent of the refinery at Bayonne.

D. L. Hines has been appointed a vice president and will continue in charge of Eastern transportation, and R. K. Kelly, in charge of the Eastern marine department, has been named an assistant vice president.

Northwest Refinery Planned

Plans for a refinery at Seattle, Washington, have been announced in connection with a contemplated 1100-mile 10-inch pipe line from Montana to Seattle, by C. O. Risen, vice president of North Pacific Pipe Line Company, Billings, Montana. Work is proposed to begin next year. Storage facilities at Renton, Washington, also are planned.



Announcing

EDWARD CAST STEEL GATE VALVES

Now

YOUR POST-WAR GATE VALVE IS READY...!

HERE is a valve that *is* tighter and *stays* tighter than you thought a gate valve could—a post-war valve development ready *now!*

Forty years a producer of steel valves for difficult operating conditions, Edward is now building cast steel gate valves for the first time. These valves are available in many sizes and pressure classes for *immediate shipment!*

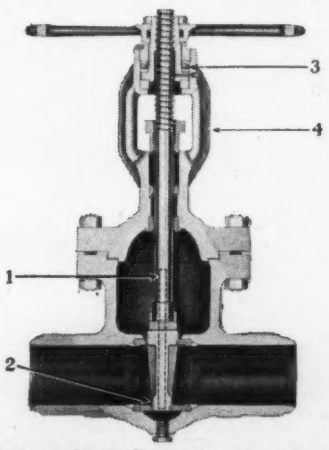
Flow is straight through and unobstructed, yet globe valve tightness is achieved through fundamental differences in design. Specially developed testing methods prevent any Edward gate valve passing test unless *both* faces, *not just one,* are absolutely drop tight *simultaneously.*

NEW CATALOG READY

Just off the press! Catalog 12-E1 with illustrations, dimensions and descriptions of Edward cast steel gate valves for 150 to 3600 lb service. Write for your copy.

✓ Check These UNUSUAL FEATURES

1. Close fitting wedge guides welded to body *after* seat rings and wedge are located to assure perfect alignment and eliminate unnecessary wear-producing drag of wedge across seating faces.
2. Perfectly positioned hard surfaced seats, integral with body.
3. Simple yoke construction with ball bearing operation even in medium sizes, EValized surfaces where abrasion is a problem, and no superfluous parts.
4. One piece bonnet for absolute alignment, easy operation, minimized maintenance.



THE EDWARD VALVE & MFG. CO. INC., EAST CHICAGO, INDIANA

EDWARD *Steel* VALVES

NEW EQUIPMENT FOR THE MODERN PLANT

Shaft Seal

CRANE PACKING COMPANY

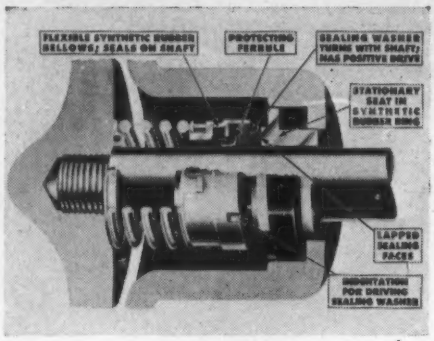
Crane Packing Company, 1820 Cuyler Avenue, Chicago 13, announces the John Crane bellows-type shaft seal, designed to eliminate stuffing-box leakage and provide perfect sealing on centrifugal pumps, refrigeration compressors, speed reducers, rotary pumps, agitator shafts and other applications.

Basically, it consists of three major parts: a flexible synthetic-rubber bellows, the tail end of which grips and seals along the shaft; a stationary floating seat, held in a synthetic-rubber sealing ring; and a positively-driven sealing washer, which turns with the shaft and is held against the stationary seat by spring pressure. The contacting faces of the washer and seat are lapped to form a leak-proof seal.

An exclusive feature is the flexing head of the bellows, which offers no resistance to the spring. This design allows the sealing washer to remain in contact with the seat as the sealing faces wear, and provides automatic compensation for shaft vibration and end-play. A protecting ferrule, fitting the shaft loosely, guides the flexing bellows head and prevents the synthetic rubber from contacting the shaft. There is no compression packing to freeze to the shaft.

The stationary floating seat used in most installations is held in a synthetic-rubber holding ring. This construction permits easy insertion, prevents stress distortion of the sealing face during installation and allows the face to be lapped before insertion, thus eliminating the difficulties involved in lapping the face in the seal cavity.

The flexible bellows and holding ring are molded of special high-grade synthetic-rubber stocks for maximum resistance to oil, hydrocarbons, refrigerants, water and anti-freeze solutions. The other parts are made of materials best suited to give maximum service and to resist the chemical action of the fluids handled.


FLEXIBLE SYNTHETIC RUBBER BELLOWS; SEALS ON SHAFT
PROTECTING FERRULE
SEALING WASHER TURNS WITH SHAFT; HAS POSITIVE DRIVE
STATIONARY SEAT IN SYNTHETIC RUBBER RING
LAPPED SEALING FACES
INDENTATIONS FOR DRIVING SEALING WASHER

John Crane Shaft Seal

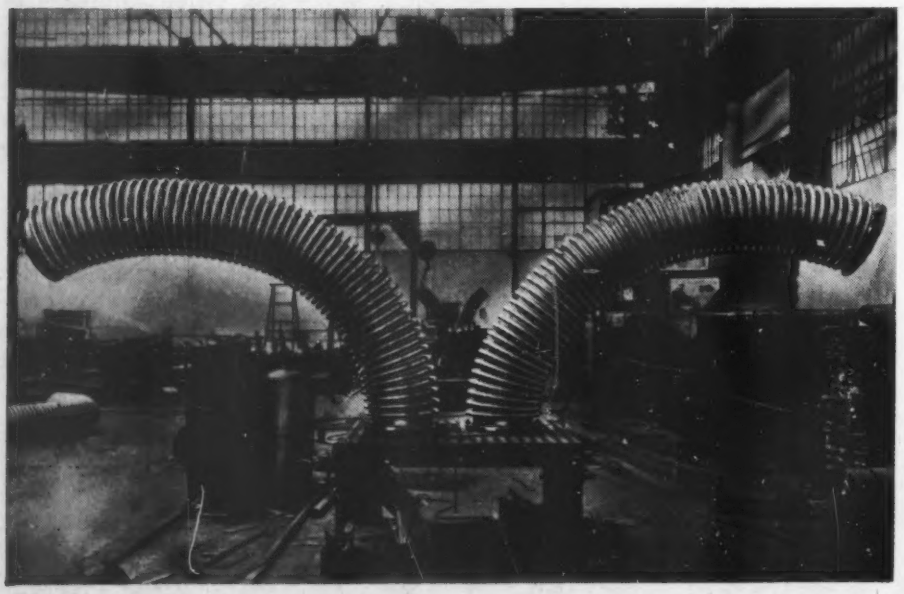
This high-precision mechanical seal is manufactured by Crane Packing Company, 1820 Cuyler Avenue, Chicago 13, Illinois. An illustrated bulletin giving full details is available on request.

Corrugated Connectors

ZALLEA BROTHERS & JOHNSON

Zallea Brothers & Johnson, Wilmington 99, Delaware, announce manufacture of large flexible corrugated stainless-steel tubing. Extensively used on diesel-engine exhaust and high-temperature vapor lines, these connectors have inherent advantages of value to the petroleum, chemical and power industries, and it remains only to apply this development to existing problems in these fields, it was pointed out.

The connectors absorb expansion, contraction and extreme deflection in all planes. Supplied in sizes 6 inches diameter and larger, in carbon steel, any type of stainless steel and other corrosive-resistant alloys, they require no packing and, having no seams, are permanently gas-tight. The connectors handle corrosive liquids and gases under pressures up to 30 pounds per square inch and at temperatures from sub-zero to 1800°F. Connectors for absorbing linear expansion only can be furnished for pressures up to 300 pounds.



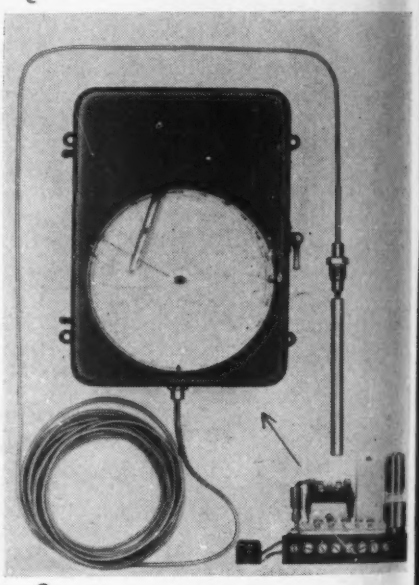
Two 10-inch diameter by 9 feet diesel exhaust connectors bent to 110, manufactured by Zallea Brothers & Johnson.

Electronic Controller

THE BRISTOL COMPANY

The Bristol Company, Waterbury 91, Connecticut, has announced its Free-Vane Electronic Controller, which operates on the shielding effect of a vane passing between two coils in an electronic circuit, recording and indicating models are offered for automatic control of temperature, pressure, liquid level, and humidity. The following types of control operation are available: low-open, high-open, low-high, low-open-high, and low-normal-high.

The new controller for temperature is offered in ranges from —125° F. to +1000° F. for use in conjunction with motor and solenoid valves, relays, main-line switches, and other fuel-control apparatus for controlling the temperature in electric, oil-, gas-fired, and steam-heated ovens, dryers, dehydrators, oil baths, smoke houses, tanks, and other similar industrial apparatus.



Bristol Electronic Controller

The pressure controller is available in ranges from full vacuum to 6000 pounds per square inch and in addition is available for automatically controlling liquid level. The humidity controller operates from a wet and dry bulb type of element with separate control for each bulb. The Free-Vane Electronic Controller is also offered as a time-program controller for automatically controlling temperature, pressure, liquid level or humidity according to a definite time schedule.

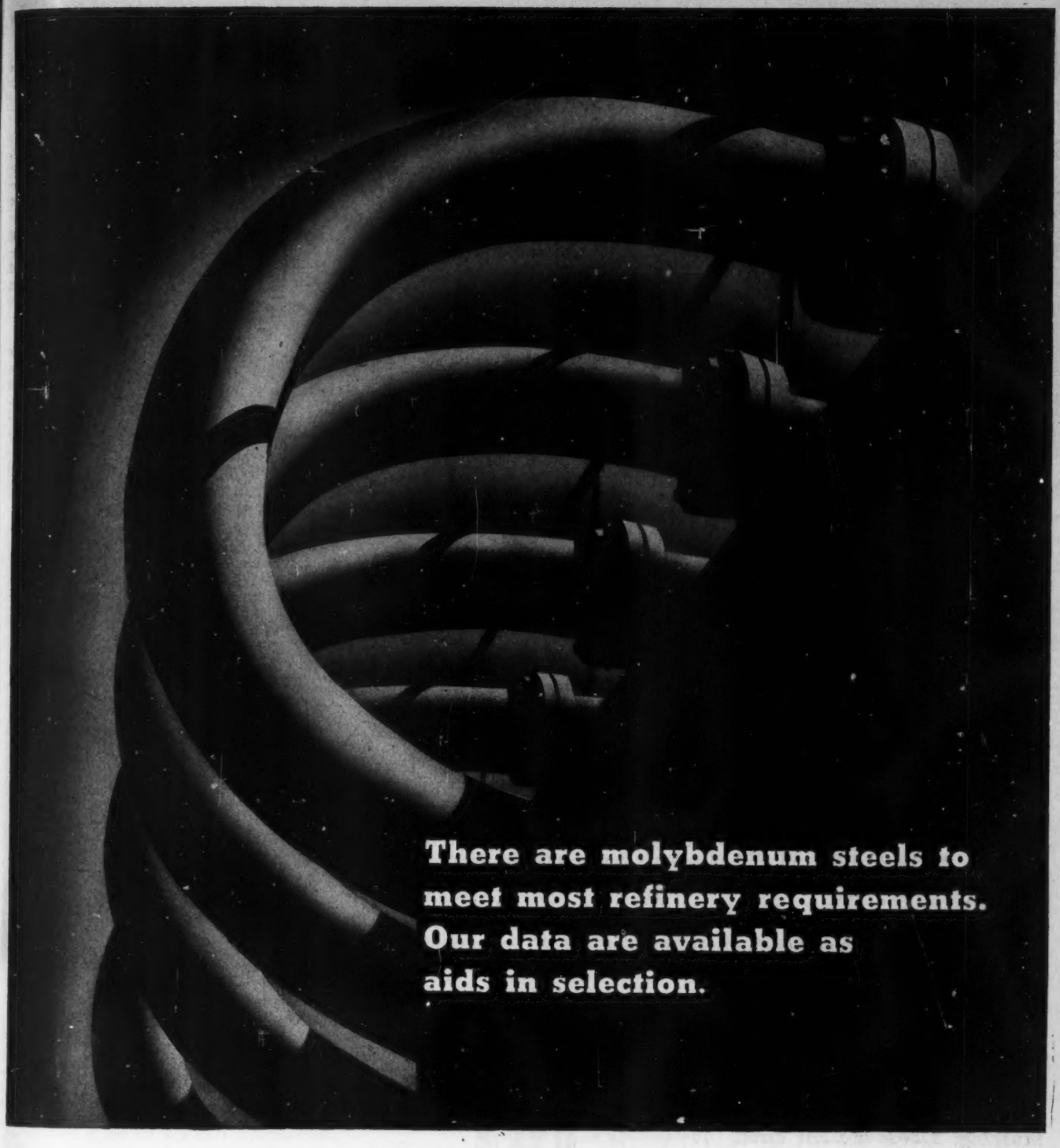
Diesel Engine

STERLING ENGINE COMPANY

Sterling Engine Company, Buffalo, New York, has announced a new line of diesel engines ranging from 250 to 650 horsepower. An important feature of the new design is that it provides a power plant with the same overall dimensions and the same weight as gasoline engines.

Models include a 6-cylinder supercharged and unsupercharged, and an 8-cylinder supercharged and unsupercharged.

The engines are four-cycle, multiple cylinder, in-line, trunk piston type, com-



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If floor cleaning is a chore in your pumping station, we can help you. Data free on request.

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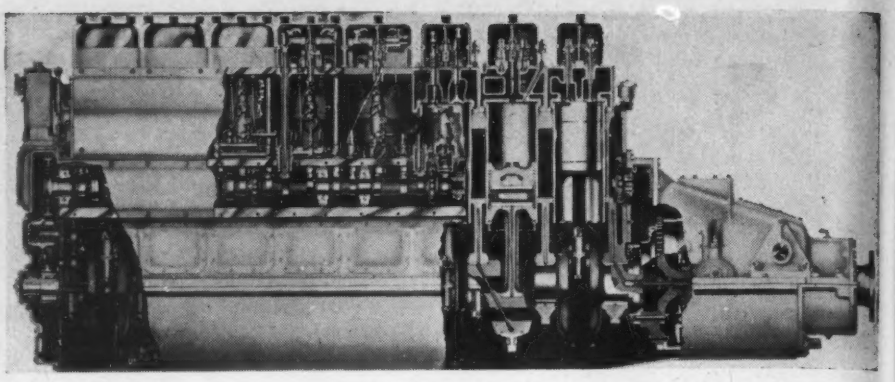


Cross section of the new Viking diesel engine developed by Sterling Engine Company

pletely enclosed. The cast cylinder block is of single piece construction, containing the crankshaft main bearings at the lower surface with the wet cylinder sleeves inserted in the upper portion of the block. The cylinder heads are arranged individually for each cylinder and are fastened to the top of the block.

Cylinder heads are provided with four valves, per cylinder, two intake and two exhaust.

The fuel-injection sysetm consists of individual pumps for each cylinder, close to each injection nozzle.

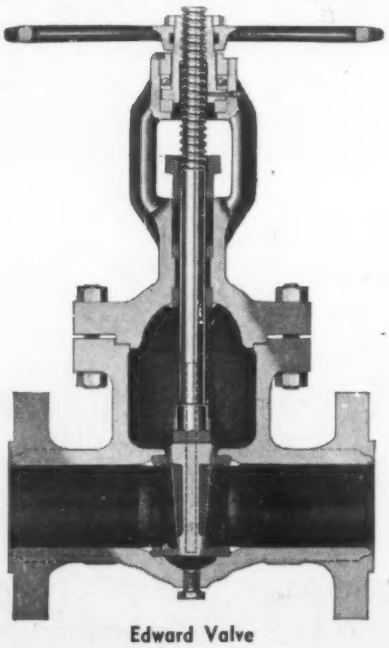
The bore and stroke for all models is 8 by 9 inches, giving a displacement of 2714 cubic inches for the 6-cylinder model, and 3619 cubic inches for the 8-cylinder type.

Gate Valves

THE EDWARD VALVE & MANUFACTURING COMPANY

The Edward Valve & Manufacturing Company, East Chicago, Indiana, announces a new line of cast-steel gate valves for which are claimed basic improvements in design. To achieve alignment of worknig parts, close-fitting wedge guide ribs are constructed by a new method to eliminate wear-producing drag across seating faces.

Seat rings of the new gate valves are hard surfaced and welded integrally to the body. Specially built fixtures permit hydrostatic test of both seating faces simultaneously. Valves 4-inch and larger are ball-bearing equipped. In the smaller sizes, bearing plates for yoke bushings are given a special plating to reduce operating effort. The new valves are built in 300-, 600-, 900-, and 1500-pound steam pressure classes, and in sizes 2½- to 12-inch, inclusive. Some sizes and pressure classes are available from stock.

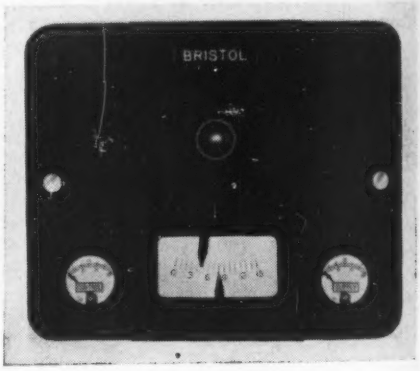


Edward Valve

Air-Operated Controllers

THE BRISTOL COMPANY

The Bristol Company, Waterbury 91, Connecticut, has announced development of a new series of indicating air-operated control instruments. The new instruments, known as the Model 93 series, are built for controlling temperature, pressure, vacuum, liquid level, and humidity.



Bristol Air-Operated Controller

Model 93 Controllers operate on the free-vane principle of automatic control. They have a throttling range of from ½ to 15 percent, with the adjusting mechanism arranged so that changes in the throttling range can be made by the user without the need of tools.

Model 93 Controllers are direct-set instruments that can be set to control at any value within the range of the instrument by turning the control pointer to the desired value. They are built so that they can be changed by a finger adjustment from reverse to direct action or vice versa.

Flow Splitting Device

FISCHER & PORTER COMPANY

Fischer & Porter Company, 1908 County Line Road, Hatboro, Pennsylvania, announces the "Micro-Rotaweir," a flow splitter designed to accurately divide a liquid flow into two streams. Proportions of the flow division may be varied by adjusting an outside lever and pointer to the percentage desired, as indicated by an external scale.

Operation of the Micro-Rotaweir is described as follows: The inlet pipe comes in from the top and discharges

Among the well known lines available to you through The CORBETT CORPORATION are:—

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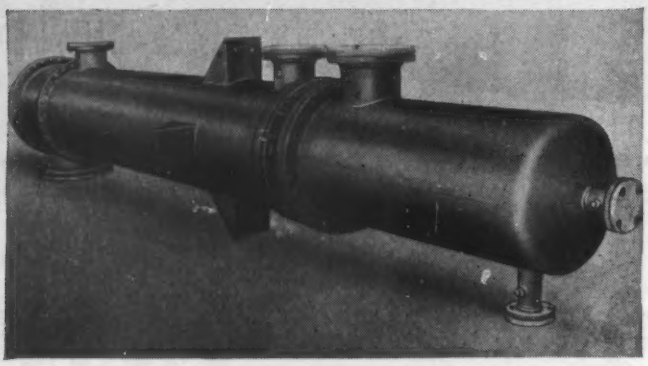

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We concede the importance of good design and intelligent specification of materials, but Downingtown's ability does not stop there.

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Our Engineering consultation is at your disposal. Downingtown Heat Transfer division has prepared a handbook which will be ready for free distribution on or about September 15. Send for a copy of this handy reference book, on your business letterhead, please.

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FIRST: Fill bucket at tank. Hook onto hoist and raise bucket on Load Lugger.

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Lower costs are on the way and you can take advantage of them in your own plant right now by utilizing a Brooks LOAD LUGGER on every one of your trucks, used for *sludge handling*. Just fill the detachable buckets at the tanks, then pick them up and dump them at the sludge pond with the LOAD LUGGER. This method is cheaper, faster and cleaner.

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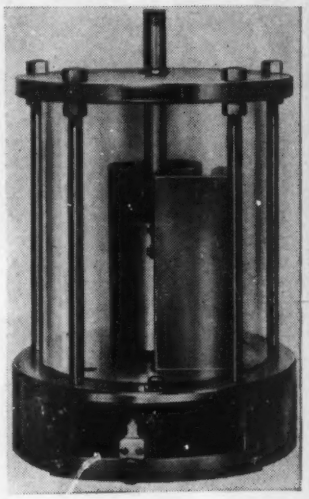
the liquid into a receiving chamber which has a rectangular weir as an overflow. A vertical knife edge is set against the external edge of the weir, thus dividing the stream into two parts as it flows over the lip of the weir. One of the streams flows into a closed compartment with bottom outlet; the other stream spills into the area surrounding the receiving chamber and discharges also from the bottom. The receiving chamber is connected through a stuffing box at the bottom to an external lever by means of which the weir may be rotated to any position with respect to the flow-dividing knife edge.



Fischer & Porter Micro-Rotaweir

The instrument may be had with fittings in all metals. The shell may be either metal or Pyrex glass. For high-melting fluids the metal shell may be lagged and steam-heating coils placed inside the Rotaweir. It will handle flows from 30 to 900 gallons per hour, and sizes up to 15,000 gallons per hour are contemplated.

Gear Reduction Units

CLEVELAND WORM & GEAR COMPANY

Cleveland Worm & Gear Company, Cleveland, Ohio, has improved its fan-cooled work gear reduction units so that smaller size units may be applied to a given installation. In some instances it is claimed that the new units offer as much as twice the capacity of the standard worm-gear units of equal frame size when operated with 1750 r.p.m motors.

In the improved units, heat generated during operation passes through the oil bath to the deeply-finned wall of the reservoir. An exhaust fan on the coupling end draws a stream of air at high velocity between the double walls that form the lower half of the unit, scouring the surface and providing an effectual transfer of heat.

Descaling Attachment

VICTOR EQUIPMENT COMPANY

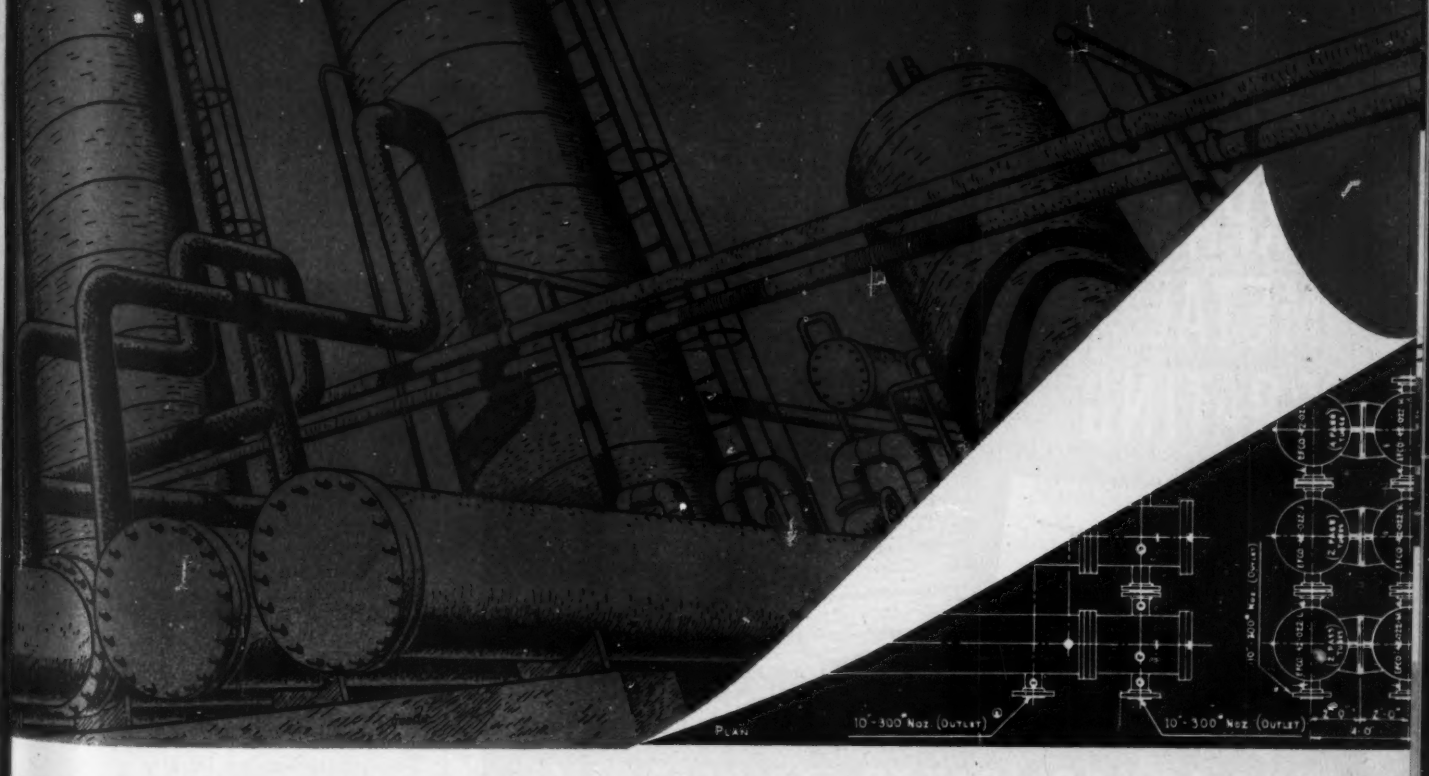
Victor Equipment Company, 844-54 Folsom Street, San Francisco, has developed a descaling attachment for any standard Victor welding torch butt.

The attachment is provided with a spiral mixer and gas proportioner to handle larger gas volumes with maximum efficiency, and assures freedom from back-fire or flash-back.

A cooling section is incorporated at the nozzle head to keep pre-mixed

EFCO

Specialists in designing and fabricating superior heat transfer equipment for 100 octane gasoline and synthetic rubber plants



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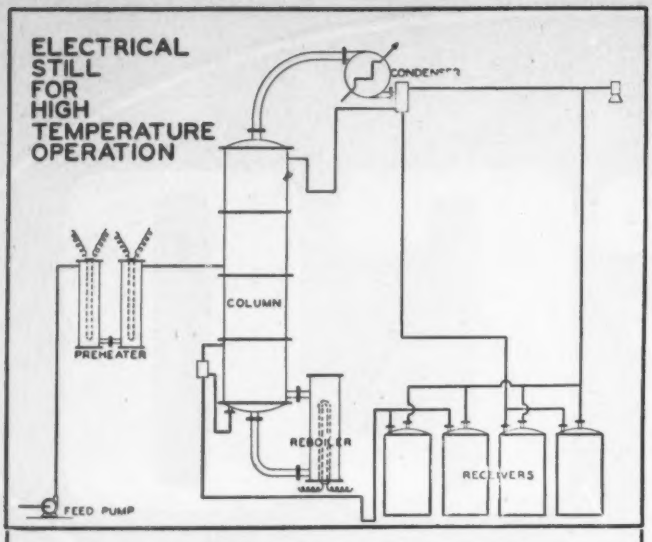

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gases below ignition temperatures, even within the proximity of the ribbon flame and deflected heat.

Replacable meehanite skid shoes with properly shaped lugs are said to add substantially to the wearing life of the nozzle and allow it to be dragged at any suitable angle over the metal surfaces to be cleaned.

Insulating Materials

THE EAGLE-PICHER SALES COMPANY

The Insulation Division of The Eagle-Picher Sales Company, Cincinnati, Ohio, has announced four new insulating materials.

Eagle Swetchek, an insulation for minimizing condensation, for use on cold water lines, water coolers and softeners, storage tanks, filters and condensers, is described as a prepared plastic coating exceptionally resistant to abrasion, and black in color.

Eagle Drycote, companion product to Eagle Swetchek in combatting condensation, is a plastic coating, white in color, and packaged in dry form. When mixed with water and applied by trowel or hand application to any clean dry surface, Eagle Drycote becomes smooth and glossy white and sets into an extremely hard surface. It is highly fireproof.

Eagle Hadesite is a fireproofing insulating cement for high-temperature work. Mixed with water Hadesite is troweled to a smooth hard finish of salmon color and is used primarily for fireproofing structural steel, lining high temperature ducts, firedoors, etc. Hadesite is used to temperatures to 1900° F.

Eagle "43" Finishing Cement is used for finishing interior insulation work where an extremely hard, smooth surface is desired. It can also be painted and withstands temperatures to 800° F.

Bunghole Light

DAY-RAY PRODUCTS, INC.

Day-Ray Products, Inc., South Pasadena, California, has announced a fluorescent light 1½ inches in diameter for inspecting drums and barrels where bungholes are the only means of access. The lighting element is a regular fluorescent bulb enclosed in a plastic housing which is insulated to make the light capable of prolonged burning under water. The light is provided with proper handle and conveniently long cord.

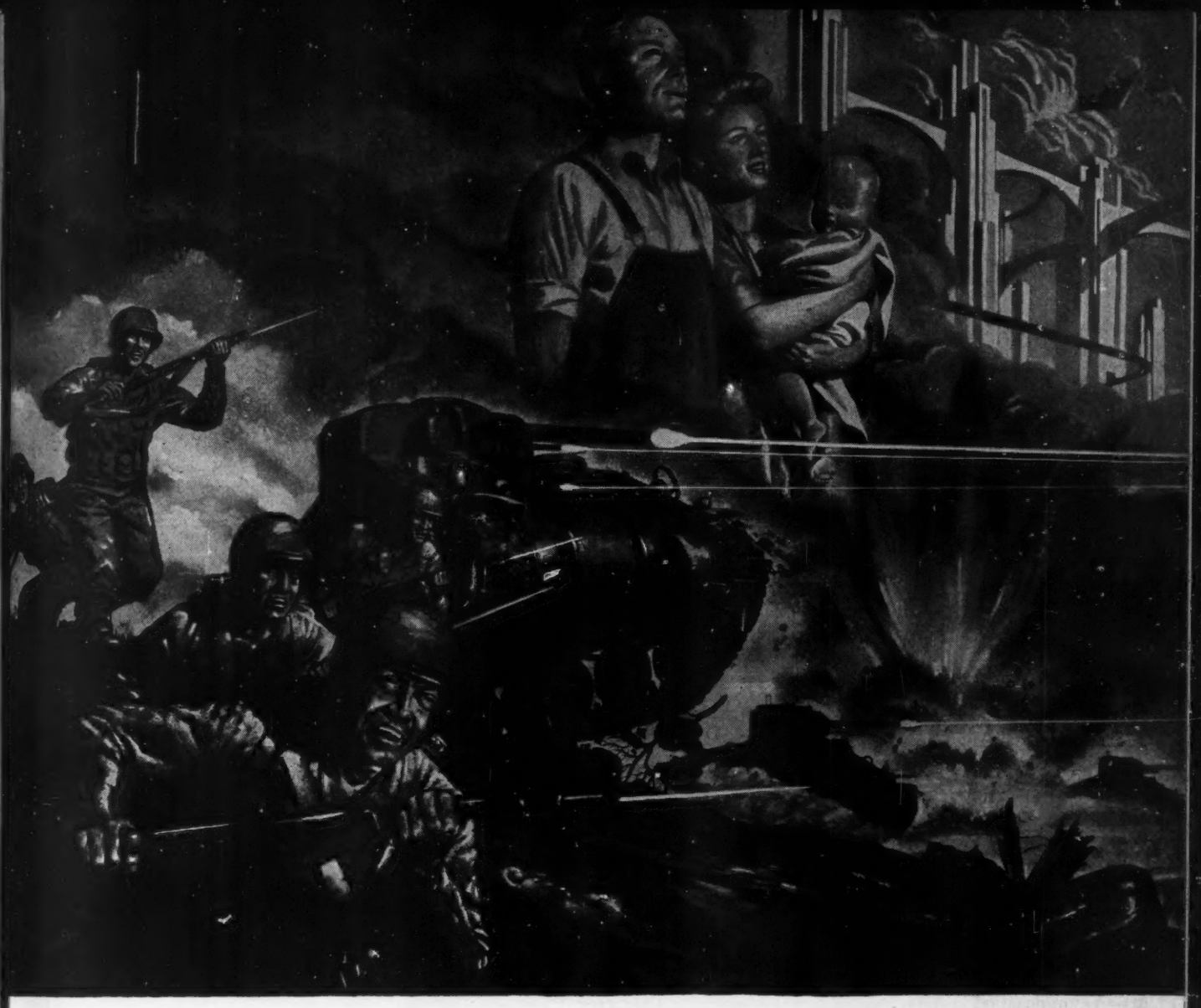
Time-Program Potentiometer Controller

THE BRISTOL COMPANY

The Bristol Company, Waterbury 91, Connecticut, announces that time-program control is now available on its Model 431 Pyromaster potentiometer pyrometer, recently developed.

These time-program controllers automatically regulate temperature, not necessarily at a fixed point, but rather carry it through a predetermined series of changing values. Blank metal cams with time and temperature graduations printed on the cam face enable the user to cut his own cams with a pair of tin snips.

The controller can be any of the five air-operated types or several electric types of control manufactured by the company, and in ranges up to 3000° F. for thermocouple-type controllers and up to 3600° F. when used in connection with the company's compensated radiation unit.

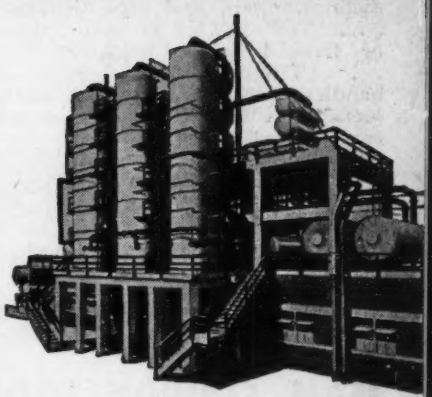


FOR THE FIGHTER... AND HIS DREAM!

The fighter must have something to fight for as well as something to fight with. It is industry's task to back him with weapons today and tools tomorrow.

Blaw-Knox makes its own long list of war weapons, as well as basic equipment to aid other manufacturers in their war efforts. When the international reconstruction program begins, Blaw-Knox will supply a wide range of equipment to speed it. Blaw-Knox leads in many fields. For example: rolls, mills and other essentials for the ferrous and non-ferrous industries . . . highly specialized fabricated products for railroads, public utilities, the electronic and construction industry and industry in general. For the chemical and process industries Blaw-Knox produces all types of equipment, even complete plant units.

Whatever your plans perhaps Blaw-Knox products and services can be useful to you. Let us discuss it at your convenience.



A typical example of Blaw-Knox design and construction for the Chemical and Process Industry.

BLAW-KNOX COMPANY

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NATIONAL ALLOY STEEL DIVISION, Heat and Corrosion-Resistant Alloy Castings

SPECIAL ORDNANCE DIVISION, Bofors Anti-Aircraft Gun Mounts and Mechanisms

PITTSBURGH ROLLS DIVISION, Rolls for Steel and Non-Ferrous Rolling Mills

POWER PIPING DIVISION, Prefabricated Piping Systems

BLAW-KNOX DIVISION, Chemical & Process Plants & Equipment, Construction Equipment, Steel Plant Equipment, Radio & Transmission Towers . . . General Industrial Products

COLUMBUS DIVISION, Ordnance Matériel

UNION STEEL CASTINGS DIVISION, Steel and Alloy Castings

MARTINS FERRY DIVISION, Bofors Anti-Aircraft Gun Mounts

BLAW-KNOX SPRINKLER DIVISION, Automatic Sprinklers and Deluge Systems

Five Blaw-Knox Plants have been awarded the Army-Navy "E" for war-production excellence

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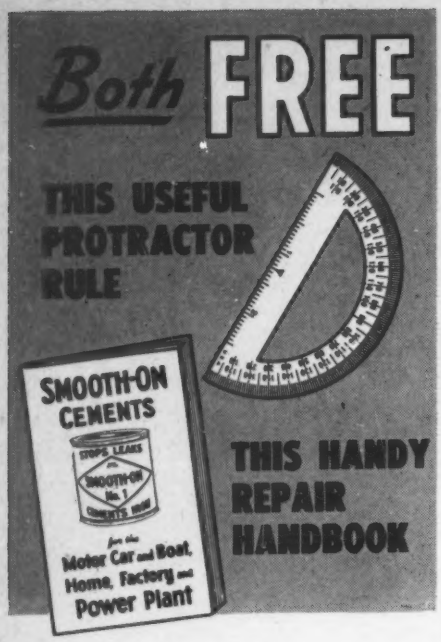
ANTI-AIRCRAFT GUN MOUNTS · GUN SLIDES · LANDING [illegible]GES · AERIAL BOMBS · POWDER PLANTS · PIPING FOR NAVAL VESSELS · SYNTHETIC RUBBER PLANTS
CAST ARM[illegible] FOR TANKS & NAVAL CONSTRUCTION · CHEMICAL PLANTS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This repair handbook shows how you can SEAL CRACKS in casings or shells of pumps, heat exchangers and other process apparatus, valves, machinery castings, pipes, and pipe fittings, etc. . . . STOP LEAKS at seams, threaded or flanged joints, bolts, rivets, etc. . . . TIGHTEN loose screws, bolts, handles, pulls, fixtures, etc., on tools, utensils . . . WATERPROOF wet cellars, concrete, brick or stone floors, walls, etc.

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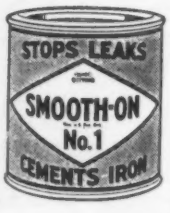

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☆ BUSINESS NOTES ☆

General American Transportation Corporation, 135 South LaSalle Street, Chicago, has appointed Thomas McLean Jasper technical and research director. For 18 years Jasper has been director of research for A. O. Smith Corporation. A native of England, he is a graduate in science and engineering from University of Illinois and also studied at University of Wisconsin. In the first world war he served with the British as a major of artillery, after which he was assistant professor of mechanics at University of Wisconsin, and associate professor of engineering materials and engineer of tests at University of Illinois for the fatigue of metals investigation under auspices of National Research Council. He is a member of ASME, ASM, API and ASTM, and has contributed to the literature on research and testing of materials. His work has included design of heavy welded pressure vessels, collapse of cylinders, stresses due to welding, and the collaboration associated with development and welding of heavy plates and special steels.

T. McL. Jasper

J. B. Beard Company, Shreveport, Louisiana, has added Clayton D. Berry to its staff at metallurgist in charge of heat treatment development and procedure in the steel foundry division. Clayton is a graduate of Marquette University (bachelor of science in chemical engineering) and of University of Wisconsin (master of science in metallurgical engineering). He formerly was metallurgist for Sivyer Steel Castings Company, Milwaukee, and previous to that was metallurgist in heat treatment for J. I. Case Company, Racine, Wisconsin. He has been active in the American Foundrymen's Association and other professional groups.

C. D. Berry

Worthington Pump and Machinery Corporation has appointed William J. Van Vleck manager of its Atlanta office, succeeding Edward Stauverman, resigned. With the company since 1924, Van Vleck has been assistant manager at Philadelphia since 1938.

Fairbanks Morse & Company, Chicago, has purchased physical assets, patents and trade marks of Pomona Pump Company, a division of Joshua Hendy Iron Works, Sunnyvale, California. Arnold G. Brown, former general manager of Pomona Pump Company, will become assistant manager of the pump division of Fairbanks Morse & Company, it was announced, and the change will not affect factory or sales personnel. Output of the acquired company will augment rather than replace the line of pumps sold by the purchaser. Plants at Pomona, California, and St. Louis, Missouri, were involved.

The M. W. Kellogg Company, Jersey City and New York, has opened a new office in the Mellie Esperson Building at Houston, with W. T. McCay in charge. McCay has been associated with the oil refining industry in the Gulf Coast area for a number of years, and the announced purpose of the office is to "keep Gulf district refiners informed through close personal contact on significant trends and advances in the field, particularly with respect to the extensive postwar studies now being conducted by the company's engineering division."

Westinghouse Electric Supply Company has appointed C. M. Mackey manager of the Southwest District with offices at Dallas, transferring from Houston where he has been branch manager since 1936. With Westinghouse since 1917, Mackey has worked in Denver, El Paso, Tulsa and Oklahoma City.

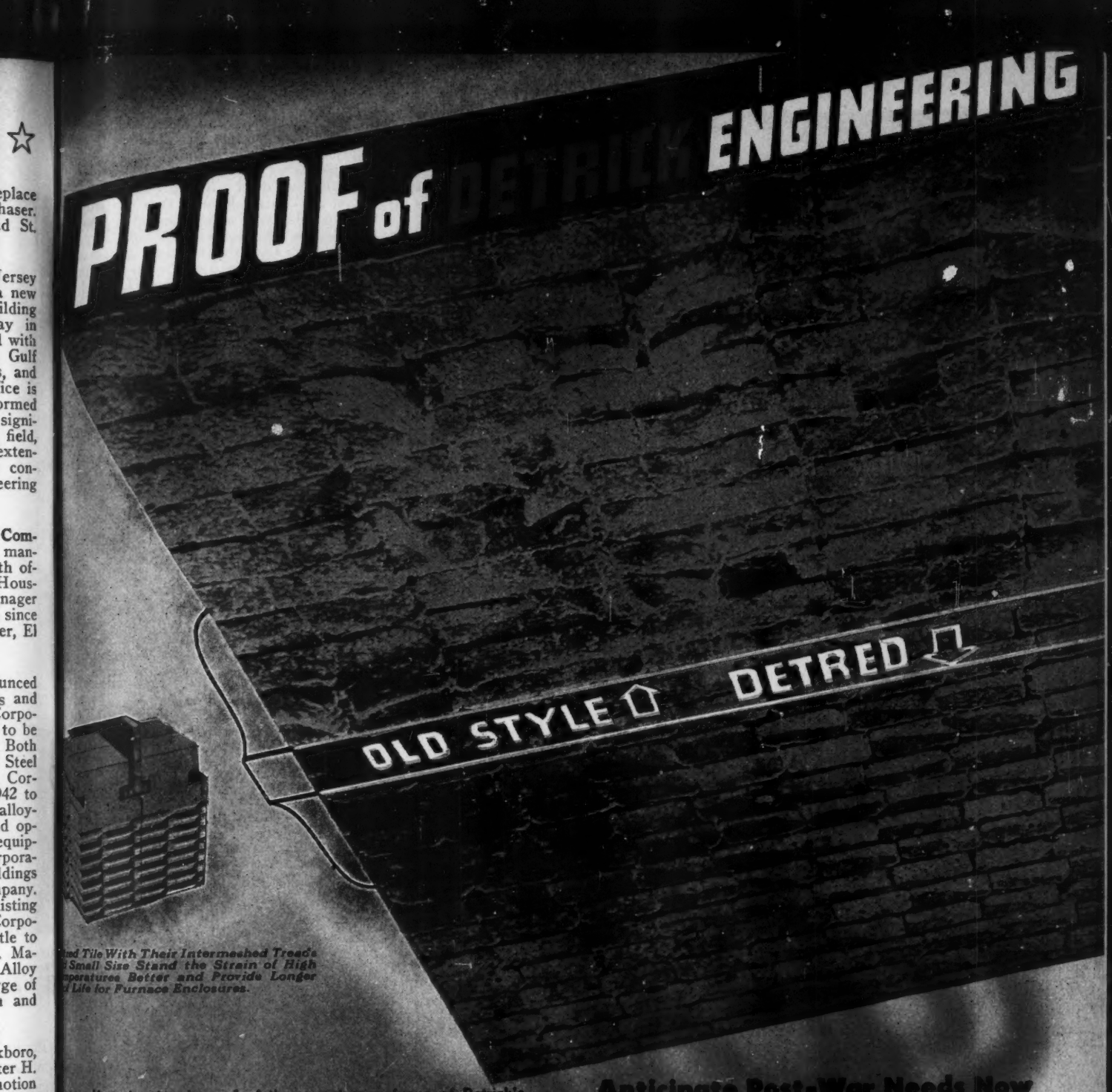
National Tube Company announced acquisition October 1 of buildings and properties of Tubular Alloy Steel Corporation at Gary, Indiana, the latter to be an operating division of the former. Both are subsidiaries of United States Steel Corporation. Tubular Alloy Steel Corporation was launched early in 1942 to increase production of seamless alloy-steel tubing for the war effort, and operated mechanical facilities and equipment owned by Defense Plant Corporation, using plant site and buildings acquired from National Tube Company. The move does not change the existing arrangement with Defense Plant Corporation which continues to hold title to the mechanical equipment. Leo J. Mason, vice president of Tubular Alloy Steel Corporation, will be in charge of the Tubular Alloy Steel Division and will retain headquarters at Gary.

The Foxboro Company, Foxboro, Massachusetts, announces that Walter H. Ridley has joined its sales promotion department at the home office. Since graduation from Massachusetts Institute of Technology in 1928, Ridley has been with manufacturers of textile machinery as designer and sales engineer. For the past two years he has been with the Boston office of WPB.

H. K. Porter Company, Inc., Pittsburgh 22, has appointed Fred Grotts, president of Fort Pitt Steel Casting Company, to additional duties as director of research and metallurgy for H. K. Porter Company, Inc., and its subsidiaries, including Fort Pitt Steel Casting Company, Mt. Vernon Car Manufacturing Company, J. P. Devine Manufacturing Company, Porter Process Division, Quimby Pump Company.

Fred Grotts

PROOF of DETRICK ENGINEERING



...nd Tile With Their Intermeshed Treads Small Size Stand the Strain of High ...peratures Better and Provide Longer ... Life for Furnace Enclosures.

Here is visual proof of the soundness of one of Detrick's construction principles, namely: small sized tile suspended, bonded and intermeshed. The photograph shows an arch in which both large tile and Detred Tile were used for the same period, under the same service conditions. Note that the larger sized tile are in most cases split and are spalling badly. The Detred area is sound and tight.

In thousands of furnaces and other heat enclosures throughout the country the soundness of Detrick engineering has been proved by the way the arches and walls have stood up under the extra over-capacity operation of war effort. It is when extra severe service is needed that the thirty years of Detrick engineering experience shows up best.

Anticipate Post-War Needs Now

It won't be long before we will all be looking for post-war business, and the wise ones are avoiding the rush. If you have plans for modernizing your present equipment or for the installation of new boilers or heaters, send your print and let our engineering department make suggestions. In the meantime ask for a copy of our 80-page catalog entitled DETRICK FURNACE ENCLOSURES which will bring you up to date on this most important subject.

M. H. DETRICK COMPANY
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If it's a problem of enclosing heat, it's a job for Detrick

DETRICK FURNACE ENCLOSURES

USE DETRICK INSULATION . . . PLASTIC or BLOCK

Maintain a Constant

UPSTREAM or DOWNSTREAM PRESSURE

No. 501. 125-pound American Standard R-S Butterfly Valve. Declutching unit (patent applied for) permits operation of the valve with either the hand wheel or the positioner cylinder.

15 to 900 psi
for air, gas, steam, liquids and semi-solids

The R-S Butterfly Valve is controlled automatically by the line pressure and is actuated by the oil or hydraulic positioner cylinder attached to the valve. If the line pressure decreases, the valve vane slowly closes until the predetermined line pressure has been reached, at which time the valve vane automatically reopens.

The dotted lines indicate the piping necessary to maintain a constant upstream pressure.

The use of an R-S Butterfly Valve as a main control valve provides unexcelled flow characteristics, simplifies performance, prevents water hammer and reduces maintenance. Operates for pressures between absolute and 900 pounds gauge. State your requirements and ask for Catalog No. 14-B.

No. 529. 30-inch R-S Butterfly Valve with extension shaft for high pressure drops and heavy duty service. Only four to six revolutions of the handwheel are necessary for wedge-type closure.

VALVE DIVISION
R-S PRODUCTS CORPORATION
120 Berkley Street • Philadelphia 44, Pa.

R-S Streamlined BUTTERFLY VALVES

pany, and Porter-Blairsville Company. Grotts will establish and head a technical and engineering advisory service for customers on materials and specifications, and direct new-product developments. During World War I, Grotts was metallurgical and chemical engineer with Curtiss Aeroplane & Motor Corporation in charge of technical processes and was cited by each of the three Allied powers for his war service. Later he was foundry manager and technical supervisor for Caterpillar Tractor Company; wheel plant superintendent for American Steel Foundries, and director of metallurgical activities for Hubbard Steel Foundry and Wheeling Mold & Foundry Divisions of Continental Roll & Steel Foundry Company. Under his direction, Fort Pitt Steel Casting Company received the first award in the nation to an electric steel foundry by the Maritime Commission, the award being three times renewed.

Ross Heater & Manufacturing Company, 1419 West Avenue, Buffalo, New York, has established a direct factory office at 901 Citizens State Bank Building, Houston 2, with John A. Coleman as manager. Following mechanical and chemical engineering study at Iowa State and Washington Universities, Coleman had 10 years experience with refineries before entering sales work in the Houston and Dallas areas 19 years ago. His work in the new connection will be sales-engineering on heat exchangers, coolers, condensers and heaters.

Jones & Laughlin Steel Corporation has advanced A. J. Hazlett from general manager of sales to vice president in charge of sales, to succeed L. M. Parsons who resigned the latter position and also as director and member of the executive committee. J. W. Reavis has been elected a director. Hazlett has been with the company since 1938, and previously was connected with West Penn Steel Company and Eastern Rolling Mill Company.

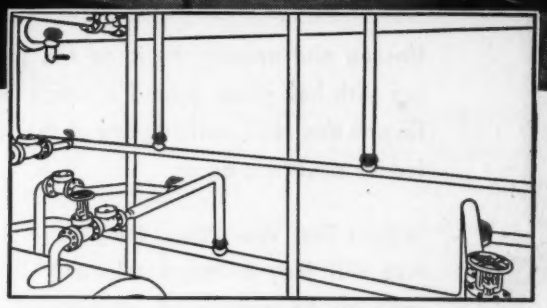
Milton Roy Pumps, 1300 East Mermaid Avenue, Philadelphia, recently has appointed these representatives: W. K. Sims, 24 Commerce Street, Newark, for Northern New Jersey; George P. Schumacher, 1120 Chester Avenue, Cleveland, for Northeastern Ohio; J. J. Heinrikson, 421 B.M.A. Building, Kansas City, for Western Missouri, Kansas, and Omaha, Nebraska, and Chas. Holz, The Industrial Equipment, Company, Charleston 23, for West Virginia.

Tube Turns, Inc., Louisville, Kentucky, has appointed Chester Herndon its manager for the Mid-Continent area with headquarters in the Commerce Building, Houston. Herndon, a graduate of University of West Virginia, formerly was associated with Hanlon-Waters, Inc., at Tulsa. At Houston he succeeds W. B. Whenthoff who has established a sales agency in Mexico City where he will represent Tube Turns and manufacturers of allied lines.

Republic Flow Meters Company has transferred Merrill Berkley from Chicago headquarters to be its representative in Southern California with offices at 742 South Hill Street, Los Angeles 14. A mechanical engineering graduate from California Institute of Technology, Berkley has been with the company and

How To Maintain FULL PIPE STRENGTH At Branch Outlets

WeldOlets are available in three types—Welding Outlet, Threaded Outlet and Socket Outlet



In a pipe job like this, branch pipe outlets must maintain the strength of the original pipe to insure safe, permanent, leak-proof joints. This is done easily by the WeldOlet method. These drop-forged fittings are shaped to fit the run pipe and are designed to provide ample reinforcement at the joint for pressures up to 400 lb. at 750° F. The factor of safety, under internal pressure, is equal to that of the pipe itself.

In addition, the scientifically designed funnel shaped opening of the WeldOlet permits unobstructed flow and a minimum of pressure loss due to turbulence and friction.

WeldOlets are available in size-to-size and reducing sizes from ¼" to 24". For information on the complete line, send for Catalog.

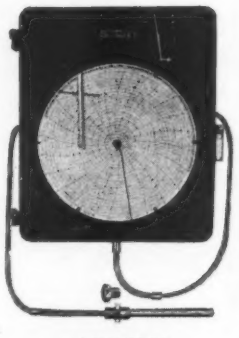
Forged Fittings Division • BONNEY FORGE & TOOL WORKS • 346 Green St., Allentown, Pa.

WELDOLETS
TRADE MARK REG. U. S. PAT. OFF. PAT. IN U. S. & FOREIGN COUNTRIES
WELDING OUTLET - THREADED OUTLET - SOCKET OUTLET
For Welded Branch Pipe Outlets

This man at the bench is not a Hero with medals and no glory awaits him when his job is done.

Unseen and unsung, he is on the job every day, working with hot glass, behind a fierce flame, with delicate fingers and skill, building one of the finest thermometers for his country's needs.

In your Post War Plans, temperature will play a major role and you can be certain of ultimate results in your manufacturing processes, IF you give serious thought NOW to using only GOOD Thermometers.



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MERCURY ACTUATED SUPERIOR RECORDING THERMOMETER

PALMER Thermometers give you:

1 . . . Precision and guaranteed accuracy;

2 . . . Sturdiness and long service;

3 . . . A bright RED column, so easy to see with "Red-Reading-Mercury."

Clip this ad as a reminder. (Catalog on request)

THE PALMER COMPANY
Makers of Industrial Recording and Laboratory Thermometers
3213 Norwood Ave. CINCINNATI 12 (Norwood), OHIO
Canadian Plant: King and George Sts., Toronto

its subsidiaries eight years on application engineering and field supervision of instruments and combustion and process controls.

The Carborundum Company, Niagara Falls, New York, announces appointment of F. Jerome Tone, Jr., as vice president in charge of sales, succeeding Charles Knupfer, senior vice president, who has been assigned to special sales and executive activities. Tone previously was vice president in charge of Eastern sales for the company.

Emery Industries, Inc., 4300 Carew Tower, Cincinnati 2, Ohio, has opened a branch sales office and warehouse at 401 N. Broad Street, Philadelphia 8, Pennsylvania, with M. Jay Veenstra as district chemical sales manager.

The Kennedy Valve Manufacturing Company, Elmira, New York has advanced Leon H. Marsh to vice president and sales manager. He has been with the company more than 25 years and has been sales manager since 1942.

Maxim Silencer Company, Hartford, Connecticut, recently was awarded a second Army-Navy E.

Luther Marsh, 49, field engineer for Taylor Instrument Companies at Tulsa, since 1925, died at Houston August 26. Born in Marshville, North Carolina, he was a graduate of University of North Carolina (Tau Beta Pi), after which he joined United States Bureau of Mines at Bartlesville where he experimented with solvent refining. He contributed a number of articles to the industry's literature and was co-author of "Handbook of the Petroleum Industry."

Worthington Pump and Machinery Corporation, Harrison, New Jersey, has secured the services of C. W. Camp as consulting electrical engineer, to replace the late Harry Wood. Camp was with Crocker-Wheeler Electric Manufacturing Company 38 years and is a former executive member of the National Association of Electrical Manufacturers.

The Mathieson Alkali Works, 60 East 42nd Street, New York 17, announces production of ammonia from a new plant at Lake Charles, Louisiana. Built by Defense Plant Corporation and operated under lease, the plant, which is one of the two largest in the country producing ammonia from natural gas, is fully engaged in war production for high explosives. After the war it is expected to produce fertilizers and anhydrous ammonia for refrigeration. In addition to ammonia, the company produces caustic soda, soda ash and synthetic salt cake at Lake Charles. Other manufacturing centers of the organization are at Niagara Falls, New York, and Saltville, Virginia. The Niagara Falls plant was pioneer producer of synthetic ammonia in this country.

National Carbon Company on October 1 opened divisional offices at New York, Pittsburgh and Chicago, which with similar offices opened a few months ago at Atlanta, Dallas, Kansas City and San Francisco completes a new sales set up under which all company products are to be handled nationally from seven district offices. F. W. Berdan is manager at New York with G. A. Blackburn and A. B. Oatman as assistants. With the company since 1922, Berdan has been an executive of the company at New York since 1929, and Blackburn

Enduro HOLDS DOWN MAINTENANCE COSTS —BECAUSE IT LASTS LONGER!

The reason why Republic ENDURO Stainless Steel cuts maintenance and replacement costs to rock bottom figures is no secret. ENDURO lasts longer—especially in applications where corrosion and high temperatures are severe.

ENDURO resists the corrosive action of most acids and alkalies —hot or cold. It resists scaling at high temperatures. And it retains its high strength—up to 185,000 p.s.i. for certain analyses—at elevated or sub-zero temperatures.

This long-lasting metal has proved its economy in many refinery applications, some of which are bubble caps and trays, baffles, still and tower linings, heat exchanger and condenser tubes, hot oil lines and pumps, and valves and valve seats. ENDURO costs more to install than less resistant materials—but it usually costs less per year of service.

ENDURO can be fabricated to practically any shape or design by all modern methods of metal working. Many equipment manufacturers use it regularly in their products. Others are glad to use it on your specifications. And your maintenance crews will be glad to use it, too, when they realize how many headaches it can save them.

Would you like literature or specific information? Write us.

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GENERAL OFFICES • CLEVELAND 1, OHIO
Berger Manufacturing Division • Culvert Division
Niles Steel Products Division • Steel and Tubes Division
Union Drawn Steel Division • Truscon Steel Company
Export Department: Chrysler Building, New York 17, N. Y.

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ENDURO STAINLESS STEEL
Reg. U. S. Pat. Off.

Other Republic Products include Upson Bolts, [illegible] — Pipe — Sheets — Plates — Electrically Welded Tubing

CORROSION

Causes Expensive Replacements

Here is a cross section of a severely corroded water cooled connecting rod of a large gas engine. This corrosion can be controlled with our Chrom Glucosates.

This is but one of the many subaqueous corrosion problems that are solved by the Haering Technical Staff.

Let a Haering field engineer survey your corrosion problems and submit recommendations without any obligation on your part.

Write for "Scale and Corrosion Control in Aqueous Systems."

Visit our Booth No. 148 Natl. Chemical Exposition, Chicago Coliseum, Nov. 15 through 19.

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Our fabrication department constructs Wire and Filter Cloth assemblies in conjunction with sheet metal, plates, bars, angles, tubes or other metal members, machined parts, as well as asbestos, rubber, fibre, plastics or textiles.

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INCORPORATED

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WIRE CLOTH
FILTER CLOTH
ALL MESHES
ALL METALS

and Oatman have been with the company since 1936 and 1916, respectively. J. A. Hammond has been transferred from assistant general sales manager at Cleveland to manager at Pittsburgh. With the company since 1923, he formerly was manager of the Carbon Products Division at Chicago. F. S. Haggerson, with the organization 7 years, and W. E. Herr, a sales executive since 1922, are assistant managers at Pittsburgh. H. A. Stewart, who has worked with the company in that territory since 1919, is manager at Chicago, with C. H. Christensen and W. L. Julian as assistants. They have been with the company 20 and 15 years, respectively.

The Pressed Steel Company, Wilkes-Barre, Pennsylvania, announces appointment of James A. Quaid as the company's district manager at Philadelphia, and will open offices in the Broad Street Station Building. Quaid formerly was sales engineer with Allegheny Ludlum Steel Corporation at Philadelphia.

J. A. Quaid

Pennsylvania Salt Manufacturing Company, Philadelphia, has organized an export department with John H. S. Barr as manager. Barr has been with the company 15 years in technical and sales capacities and recently made an extended visit to Brazil and other Latin American countries in the course of a study the company has made of trade possibilities after the war.

National Tube Company announces appointment of Louis W. Mason as assistant to its general manager of sales, with headquarters at Washington. Mason formerly was purchasing agent for Tubular Alloy Steel Corporation, Gary, Indiana. Both companies are subsidiaries of United States Steel Corporation.

Tube Turns, Louisville, Kentucky, announces that Wilbur E. Geiser has returned to his post as manager of its Philadelphia office, Broad Street Station Building, after eight months with the scheduling department of the War Production Board's valve and fittings section at Washington. Geiser's 15 years' association with Tube Turns includes considerable shop experience as well as sales contacts.

H. K. Porter Company, Inc., Pittsburgh, has announced purchase of Fort Pitt Steel Casting Company, McKeesport, Pennsylvania. The latter will be operated as in the past under direction of Fred Grotts, who was president of the company.

Aluminum Company of America has announced appointment of three assistant general sales managers and four product managers. R. K. Davies will have charge of engineering sales development activities; R. B. McKee will be in charge of direct sales offices and direct selling, and Donovan Wilmot in charge of product manager activities and warehouse distribution. All the foregoing are assistants under George J. Stanley, general sales manager. Henry L. Smith, Jr., formerly manager of casting sales, has been made product man-

CALAPOR

CAPTAIN PRODUCTS

Distributors of

K-LO INSULATING BLOCKS

A new development in a molded insulating block which provides exceptionally high efficiency coupled with unusual structural qualities and lightness in weight. Applicable to temperatures up to 1600 degrees. The K-Lo Insulating Block may be used as a structural medium and an insulation combined.

Available for immediate delivery from our Houston factory.

COMPANION PRODUCTS:

CALAPOR LONG FIBRE INSULATING AND FINISHING CEMENT the covering capacity of which is 46 sq. ft. 1 in. thick per 100 pounds.

CALSEAL FIBRATED EMULSION for weatherproofing. Fewer pounds give greater coverage.

Available for immediate delivery from our Houston factory.

CALAPOR MANUFACTURING CO.

Office: Hibernia Building, New Orleans, La.

Factory: 5521 Clinton Drive, Houston, Texas

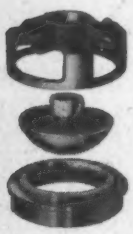
MEMO

Try a set of Royal Crowns on that tough pumping job.

Royal Crown PUMP VALVES ARE BALL-GUIDED SPHERICAL VALVES. IN PRINCIPLE THEY ARE SIMILAR TO THE OLD BALL VALVE EXCEPT THAT THEY ARE LIGHT, BUOYANT AND PERFECTLY BALANCED.

. . . THIS BALL-GUIDED SPHERICAL VALVE ROTATES AND SWINGS: IT DOES NOT RESIST THE FLUID IN THE PUMP.

. . . GUIDED BY THE BALL STEM, THE VALVE CANNOT BIND IN ANY POSITION. FREE ACTING, IT RELEASES THE FLOW INSTANTLY AND SEALS THE FLOW INSTANTLY.



. . . VALVE AND SEAT ARE INDIVIDUALLY GROUND: THEY ARE MATCHED AND LAPPED TOGETHER. ROTATING AND SWINGING, THEY CONTINUE TO LAP IN AS THEY WEAR. THERE ARE ONLY THREE PARTS —CAGE, VALVE, AND SEAT. NO SPRINGS TO BREAK! NO CROSS-BARS IN THE SEAT.

. . . NINE FACTORY STOCK METAL COMBINATIONS ARE AVAILABLE INCLUDING: SILICON BRONZE, CAST STEEL, NICKEL CHROME ALLOY IRON, NI-RESIST, STEEL, ALUMINUM BRONZE, STAINLESS STEEL, AND MONEL.

. . . ROYAL CROWNS ARE MADE IN FIFTEEN SIZES FOR EITHER SCREW FIT OR PRESS FIT. WHEN ORDERING GIVE NAME, SPECIFICATIONS AND SERIAL NUMBER OF PUMP.

Catalog Available

MADSEN IRON WORKS
HUNTINGTON PARK, CALIFORNIA

ager of sheet, to succeed Wilmot. Wiser Brown, vice president of American Magnesium Corporation (subsidiary) has assumed additional duties as manager of sand and permanent-mold castings, where he succeeds Smith. Hugo T. Wilder, district manager at Newark, New Jersey, becomes product manager for ingot, to succeed Davies. Roswell B. Whidden, Chicago district manager, has been made manager for tubing and extrusions, to succeed McKee.

Carrier Corporation, Syracuse, New York, announces that Frederick W. Smith will join that organization November 1, after 19 months as chief of the special equipment branch of the general industrial equipment division of the War Production Board. Before going to Washington, Smith spent 16 years with Frigidaire Division of General Motors Corporation, most recently as New England manager of the commercial-refrigeration and air-conditioning divisions of the company.

Caterpillar Tractor Company, Peoria, Illinois, has named W. K. Cox assistant general sales manager.

Cox joined the company in 1928 as a special representative in logging sales and turned to industrial and general sales work in 1932. In 1936 he was assigned to the advertising department and a year later returned to sales as assistant manager of the sales development division. He was named assistant sales manager of the eastern division in 1941 and became manager of that division in 1943. William S. Ziegler, field representative for the company since 1929, and assistant sales manager of the eastern division since early in 1944, has been named sales manager. F. D. Haberkorn, Texas and Oklahoma representative, has become assistant sales manager of the eastern division.

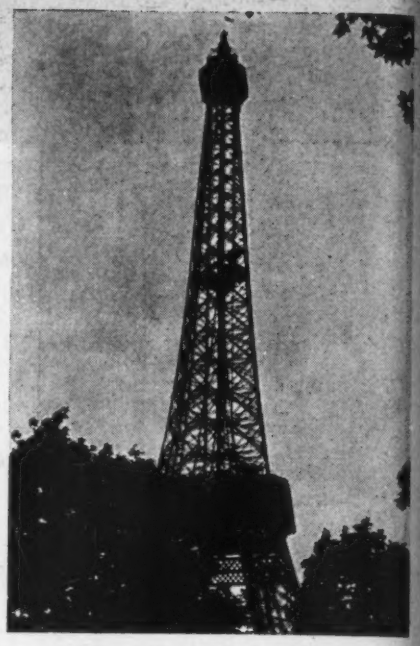
Westinghouse Electric & Manufacturing Company has announced appointment of J. H. Jewell as manager of the Industry Departments of the company. He has been with the company since 1920 in sales activities in the East.

Acetyl Peroxide Made Safe for Industry

A process for making solutions of acetyl peroxide, which are safe to handle, has been developed by Buffalo Electro-Chemical Company, Buffalo, New York.

This chemical, one of the most simple organic peroxides, has been the subject of many investigations for over 80 years. It was first prepared by Brodie in 1863 who reacted barium peroxide with acetic anhydride in ether solution. Vanino, Clover, Richmond and others continued this work, and in 1909 Gambarjan succeeded in preparing acetyl peroxide by reacting sodium peroxide with acetic anhydride. He studied the properties of acetyl peroxide and describes the product as highly explosive. Later on Kharasch describes acetyl peroxide as "an outstanding peroxide of great usefulness," but adds that it has to be "used on the spot (of manufacture) because of its sensitivity."

With developments in the production of synthetic plastics and elastomers in recent years, acetyl peroxide has again come to the foreground, as it was found to be one of the outstanding polymerization catalysts. Since 100 percent acetyl peroxide cannot be shipped, used, or even manufactured on a large scale,



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The Paris wells are 3,000 feet deep, with their corrosive proof, Layne built shutter screens set in the famed green sands formation. They were installed in 1928-29 by Layne-France Company, one of Layne's many affiliated companies. The city officials of Paris, after thorough investigation, selected Layne Wells and Pumps from a field of the keenest world-wide competition. Their confidence in the equipment has been more than justified.

Today in liberated Paris, rebuilding is already under way, but little or no work will be required to keep Layne Wells and Pumps spinning merrily along and producing ample quantities of water.

Layne Well Water Systems have also made great records in other war zones; Dakar, Tunis, Casa Blanca and London. They have long lasting quality that more than amply fits them for any peace-time need.

For late literature, address Layne & Bowler, Inc., General Offices, Memphis 8, Tennessee.

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Three flat cars were put in service for moving a pressure tower from the plant of Tulsa Boiler & Machinery Company to its site in West Texas, where it will be part of synthetic rubber ingredient processing. The vessel measured 149 feet and 20 inches, width 13 feet 5¼ inches.

Buffalo Electro-Chemical Company carried out research to overcome these difficulties. The product now available is a 30-percent solution of acetyl peroxide in dimethylphthalate. This solution is a water-white, non-explosive liquid, immune to shock and impact. It represents a form of acetyl peroxide that is suitable for commercial purposes and that can be handled with ease and safety.

Besides its value as a polymerization agent, other interesting applications include its use as a germicide, a bleaching and oxidizing agent, and in vulcanization. It has possibilities in organic syntheses as it is very reactive and offers a source of active oxygen in a non-aqueous medium.

Solutions of acetyl peroxide can be supplied, at present, in research quantities only. As soon as equipment can be installed, the product will be available in commercial quantities.

Commercial Production of Silicone Fluids Announced

Liquid silicones are in quantity production, it was announced recently by Dow Corning Corporation, Midland, Michigan. These new organo-silicon products have been available under the name of Dow Corning Fluids but their use has been restricted to a few applications essential to the war effort. Recent expansion in production permits them to be offered for adaptation to any war use indicated by their unusual combination of properties.

Dow Corning Fluids are water white and are characterized by an extremely low rate of viscosity change with temperature, compared to petroleum oils of equivalent viscosity. They also have higher flash and fire points and a complete freedom from solvent or swelling effect on synthetic or natural rubber and on many kinds of plastics. They are not affected by oxygen under pressure at ordinary ranges of temperature. Since they are resistant to oxidizing solutions, mineral acids, salts and alkalies, they have proved to be highly useful as an impregnant for asbestos packing and gaskets in chemical pumps.

Two series of Dow Corning Fluids are available depending upon the temperature and viscosity range to be covered. Dow Corning Type 200 Fluids are useful down to —40° C. or up to 200° C. and include medium through very high viscosity liquid silicones. They are non-volatile and possess flash points in excess of 600° F. They are not miscible with alcohol glycol, glycerin or lubricating oil but will blend readily with most of the common organic solvents including light naphthas.

For extremely low temperature uses, Dow Corning Type 500 Fluids include liquids ranging in viscosity from that of water to medium viscosity fluids. They are all useful at temperatures down to —70° C. and below. The very low viscosity fluids are distillable and have appreciable vapor pressures at room temperature but higher viscosity fluids in this series are non-volatile and useful up to 200° C.

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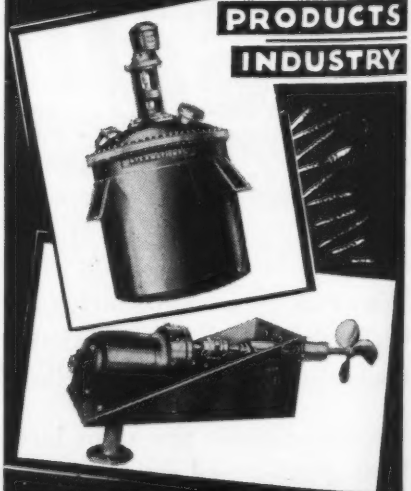

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